VERTICAL COORDINATION ARRANGEMENTS: SOME ALTERNATIVES FOR THE UNITED STATES DAIRY SUBSECTOR

BY

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Milk production in the United States has surpassed commercial consumption. The government stands ready to buy all excess supply, which is, conveniently, transformed into cheese, butter, and nonfat dry milk. Milk is one of the few major farm commodities in the U.S. with a price support program that has never been subject to production control policies.

The objective of this study is to examine some alternative arrangements to reduce milk production in the United States. The assumption made is that the subsector could, as an alternative to additional government measures, coordinate itself to reduce milk production.

The model constructed contains derived demand equations for fluid and commercial manufacturing milk, supply equations for fluid eligible

and grade B milk, and quantity and price conditions.

Corresponding equations are estimated using pooling cross-sections over time series techniques. The sample price elasticities are (a) fluid milk derived demand, -1.195, (b) commercial manufacturing milk derived demand, -4.433, (c) supply of fluid eligible milk, .24, and (d) supply of grade B milk, 1.23. Simulation results are compared to solutions obtained for the fourth quarter of 1980.

It is calculated that, if self-regulation had been selected, fluid eligible milk producer's revenue would have decreased .51 percent for one percent reduction in quantities supplied. However, if government control had been necessary, then fluid eligible milk producers' revenue could have decreased by 3.77 percent. In case the government had reduced the supported price, relatively large percentage decreases in grade B milk quantities supplied would have occurred. Nevertheless, one percent decrease in quantities supplied would have decrease grade B farmer's revenue only 1.74 percent. It was calculated that some of the government measures could have reduced grade A farmers' revenue by $59 million (1967 prices) beyond that necessary to reduce milk supply with self-coordinating measures.

Within these lines it is suggested that government should anticipate its intention to reduce its milk purchases with clear figures. Dairy cooperatives' importance as a means of coordination should be better understood and enhanced, and milk producers need to understand

that additional government rules to enforce reductions on quantities supplied are not their best alternative.

CHAPTER I
INTRODUCTION

A marketing problem in the U.S. dairy subsector is allocating milk produced to available outlets. The economic solution of this marketing problem depends on the structural relationships derived from the objectives pursued by participants in the exchange function of its marketing segment, and on mechanisms of coordination created by the government. The government directly sets minimum prices that plants must pay for milk (Federal and state marketing orders), supports manufactured dairy products prices, and establishes rules for the exchange of milk between producers and first handlers (See Glossary in Appendix B). Such mechanisms and the unrestricted outlet offered by Commodity Credit Corporation (CCC) purchases have permitted the allocation, at the supported prices, of all crude milk produced [Cook and Hayenga, 1981, p. 19; Boynton and McBride, 1980b, p. 24].

Continuous purchases of cheese, butter, and nonfat dry milk by CCC, reflecting persistent overproduction of milk, indicate a vertical coordination problem. According to Boynton and McBride [1980b, p. 6], an effective coordinating mechanism should facilitate the flow of accurate information between exchange partners. The subsector coordination problem seems to be that information generated from transactions between sellers and buyers of crude milk do not reflect their ex-ante

expectations. The government would like the dairy farmers to produce according to the commercial demand only [USDA, 1982a]. However, the actions of milk producers indicate that they have been adjusting their economic decisions to the total market demand for milk, which includes commercial demand plus government purchases.

Some of the consequences brought forth by the current dairy environment are as follows: (a) from May 1979 through December 1981 there has been increased milk production over the previous year [USDA, 1977-1981e]; (b) in 1980 and 1981 CCC net purchases of milk equivalent were 8.8 billion and 12.6 billion pounds, respectively [USDA, 1982b]; (c) the 1982 price support of $13.10 per hundredweight will cost nearly $2 billion to the government which will buy some nine percent of the Nation's milk production [USDA, 1982a]; (d) the USDA anticipates it will spend up to $4 billion between fiscal years 1983 and 1985, up from $46 million in 1979 [USDA, 1982b], and (e) as of April 9, 1982, the government had the following in stock: 365 million pounds of butter, 625 million pounds of cheese, and 975 million pounds of nonfat dry milk [USDA, 1982].

"That's the problem in a nutshell . . . we have enough surplus to fill an average-size train stretching from Washington, D.C., to New York City" [USDA, 1982a]. "This is embarrassing . . . it's unacceptable . . . , it's intolerable! It cannot continue," said John R. Block, the U.S. Secretary of Agriculture, describing the administration's view of the current price support program costs [NMPF, 1981].

Two distinct sets of measures have been suggested to alleviate surplus problem. One set consists of marketing disposal strategies

to reduce the accumulated surpluses. It includes reduction of imports, increase in exports, expansion of domestic consumption through promotion and advertising, and increasing distribution of surplus dairy products to needy consumers. The other set consists of measures directed at controlling production in order to reduce additions to surpluses. These include producers' input control plans, class I bases, taxing output, and alternative classified plans.

The first set of measures may be adequate in the short run [Brandow 1977, p. 266]. Such measures may reduce the stocked surplus, but they avoid the core of the problem, which is to improve vertical coordination in order to reduce the formation of the persistent differences between quantities supplied and demanded of milk.

Milk is one of the few major commodities with a price support program in the U.S. that has never been subject to production control policies. Analogies drawn from other agricultural commodity studies are not adequate because of the unique characteristics of milk production, distribution, consumption, and regulatory devices. An investigation of the impacts of production control measures on the subsector is now necessary.

Statement of the Problem

The problem to be examined in this study is the impact of alternative exchange arrangements on the supply and demand balance of milk between dairy farmers and manufacturers of dairy products.

Statement of Objectives

Alternative coordinating arrangements that can be used to balance the United States supply and demand for milk will be examined. Comparisons between alternatives will be made by measuring the U.S. farmers' revenue foregone under each alternative. Four stages will be necessary to accomplish such a purpose. The objectives of each stage are as follows: (a) to develop a conceptual framework of the coordinating process among processors, manufacturers, cooperatives and dairy farmers in the United States; (b) to describe the derived demand functions for fluid and manufacturing milk, and supply functions for fluid eligible and grade B milk, for the United States, which constitute the structural equations of the model referred to in objective (a) above; (c) to econometrically estimate these supply and demand functions; (d) to stimulate, using the model built in objective (a) and estimated in objective (c), the impact on milk market equilibrium values and on milk producers' revenue for each alternative coordinating arrangement studied.

Summary and Overview

Having introduced the problem that will be addressed in this study and delineated the research methodology, Chapter II will be used to review the studies which provided structural foundation for this project. Comments will be made on their strengths and weaknesses. Chapter III will contain the conceptual model in both graphical and mathematical forms. The empirical model is formulated and estimated in Chapter IV. In Chapter V the simulations of alternative coordinating

arrangements to reduce milk surpluses are ampirically examined with the estimates obtained in Chapter IV. Summary and conclusions follow in Chapter VI.

CHAPTER II
LITERATURE REVIEW

Introduction

The first chapter was used to introduce the research problem and the major objectives of this study. This chapter provides a review of the literature that constitutes the foundation of the model that will be used to measure the impacts of alternative coordinating arrangements on the balance between supply and demand of milk in the United States.

Dairy Policy Models

The research objective directed the selection of the econometric models to be investigated as a potential analytical framework for this study. The coordinating arrangements of interest must be situated in an environment which considers all the current government regulatory devices unchanged. Therefore, only the models that include the classified pricing, pooling provisions, and the price supports would be, in principle, useful for this analysis. The Kessel model [1967], and its extensions by Ippolito and Masson [1978] and Dahlgran [1980], have such characteristics. They were designed to measure the social costs of regulation. The models specifically related to features of the price supports program are the Buxton and Hammond model [1974], and the Hein model [1977]. Models that are related to the coordination approach are

also reviewed, as the Boynton and McBride plan [1980a] and the USDA's Food and Agriculture Policy Simulator (FAPSIM) [Salathe, Price, and Gadson, 1982]. The shortcomings of these models will be indicated and will be used to make selective modifications. The literature review is also extended to supply and demand equations previously estimated for the U.S. dairy subsector. A summary of the major shortcomings is provided at the end of the chapter.

Kessel Model

In 1967, Kessel designed a model that incorporated some basic features of the regulated grade A milk market, which are the classified pricing and pooling provisions.

With the price of fluid milk PI^*, as in Figure 1, QI^* would be consumed. The schedule DI is the demand for fluid milk derived from the retail level. Producers of grade A adjust production with respect to the supply function SA. The price farmers receive for grade A milk is PA^*, which is a weighed average of the class I and class II prices. The weights are the relative amounts of milk used in each class. The class II price PII^* is given to the grade A milk market. It could either be assumed to be the world price,as did Kessel, or the support price for manufacturing milk. The blend price function is AR. Finally, PA^*, QII^*, and QA^*, in this regulated grade A milk market, are thus determined by the system

(2.1) $PA = (PI\ QI + PII\ QII)/(QI + QII).$

(2.2) $QA = SA[PA]$

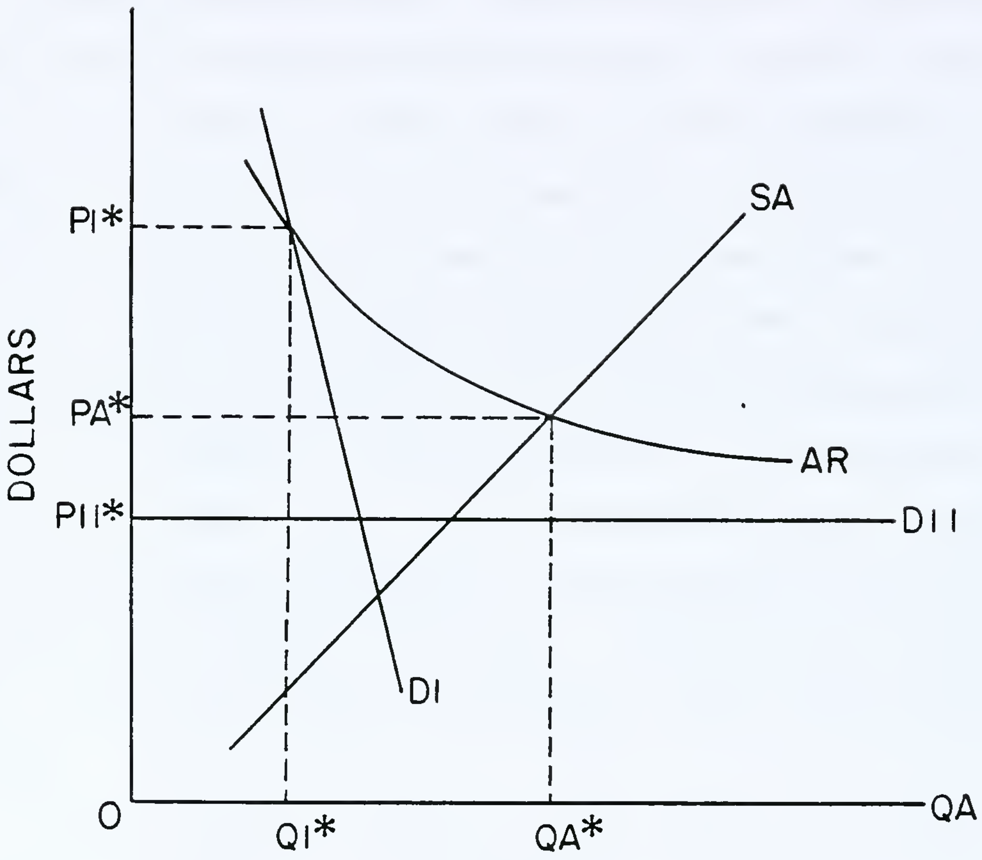


Figure 1. Kessel Model of Regulated Grade A Milk Market

(2.3) $QI = DI[PI]$.

(2.4) $QA = QI + QII$.

(2.5) $PI = PI^*$.

(2.6) $PII = PII^*$.

Kwoka [1977] used Kessel's model and previously estimated elasticities to test the common hypothesis that Federal regulation sets milk prices so as to benefit producers and to estimate the quantitative effects of regulation on prices and quantities within markets, on price patterns among markets, and income distribution and economic efficiency.

With respect to this second objective note that PI would equal to PII in the absence of classified pricing, since the blended price, PA = PI = PII (Figure 2). The world price PII' would determine QI', QA's, and QII' = QA' - QI'. In moving from this solution to the regulated solution, Kwoka estimated that "several hundred dollars are transferred from consumers to producers. Regulation also causes deadweight losses to the economy totaling $55 to $180 million annually" [p. 380].

Kessel succeeded in modeling the dairy industry classified pricing and pooling provisions. Kessel first illustrated the average revenue curve (AR), which will be used throughout this study. The major shortcomings of Kessel's model are that it does not explicitly include the entire manufacturing milk market. Also, as pointed out by Dahlgran [1980, p. 53], Kessel did not empirically estimate his model. Kwoka's estimations were based on 1960 and 1970 data, which are now considered

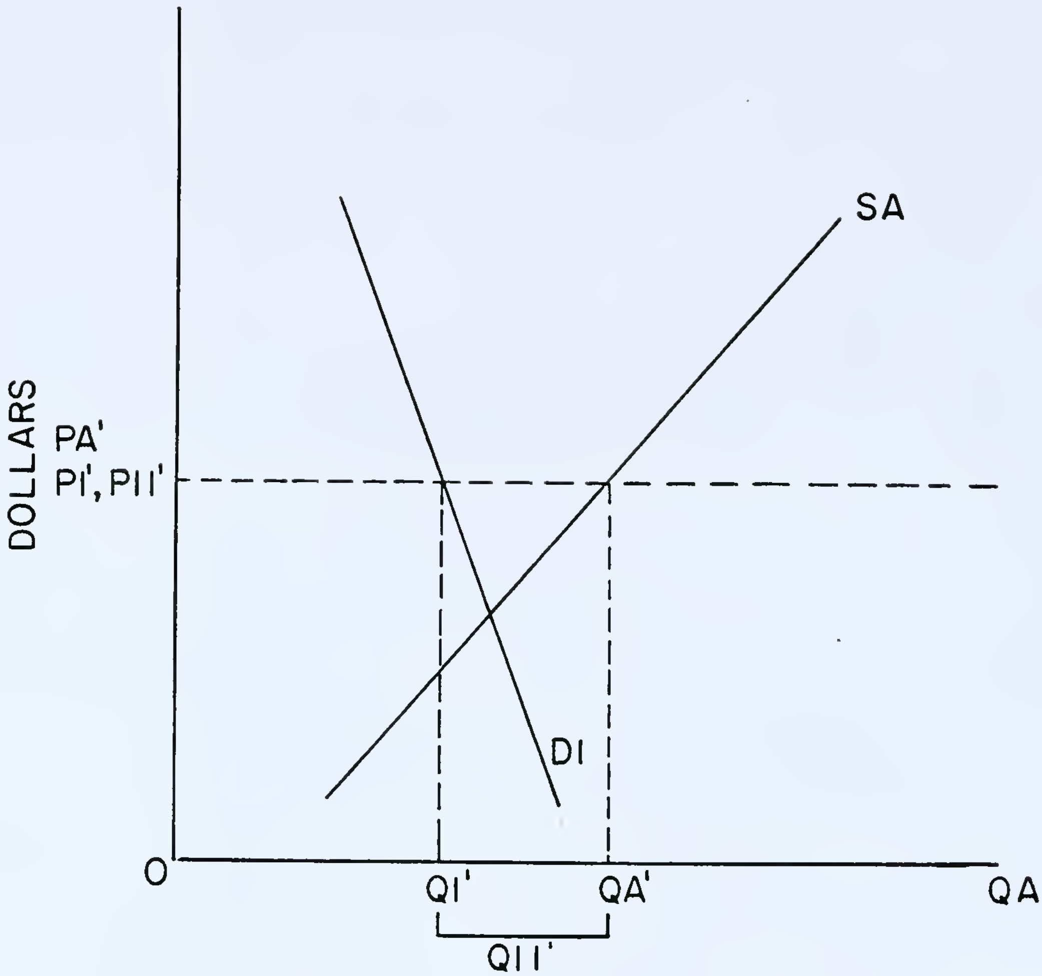


Figure 2. Kessel Model of an "Unregulated" Grade A Milk Market

old statistics since they did not capture new trends and adjustments in the subsector.

Ippolito-Masson Model

Ippolito and Masson [1978] developed a model for regulated milk markets in the United States. They used the model to simulate the inefficiencies and transfers inherent in regulation.

The analysis performed by Ippolito-Masson covers "only price regulations and does not treat the price support system" [p. 34]. However, the model has some features not incorporated in Kessel's analysis, and so it will be reviewed as well.

As in Kessel's model, DI, SA, and AR (See Figure 3) are the fluid milk demand derived from retail level, the grade A milk supply, and the average revenue curve, respectively. But DII, the class II demand function, now takes a negative slope. The important extension of this model is the interaction between grade A and grade B milk markets introduced by the authors. A supply curve for grade B milk produced in the Minnesota-Wisconsin area, SB, was added to their model.

The equilibrium in the regulated market is described in Figure 3. The quantity, QA^*, of grade A milk, as well as the blend price PA^* are determined when AR intercepts SA. Recall that PI^* is the minimum price for class I determined by the market order administrator. When QA^* is produced, PII^* is the price determined for the total demand [DII + $DI(PI^*)$] and is also the price that will be received by grade B milk farmers for each unit of the quantity QB^* produced.

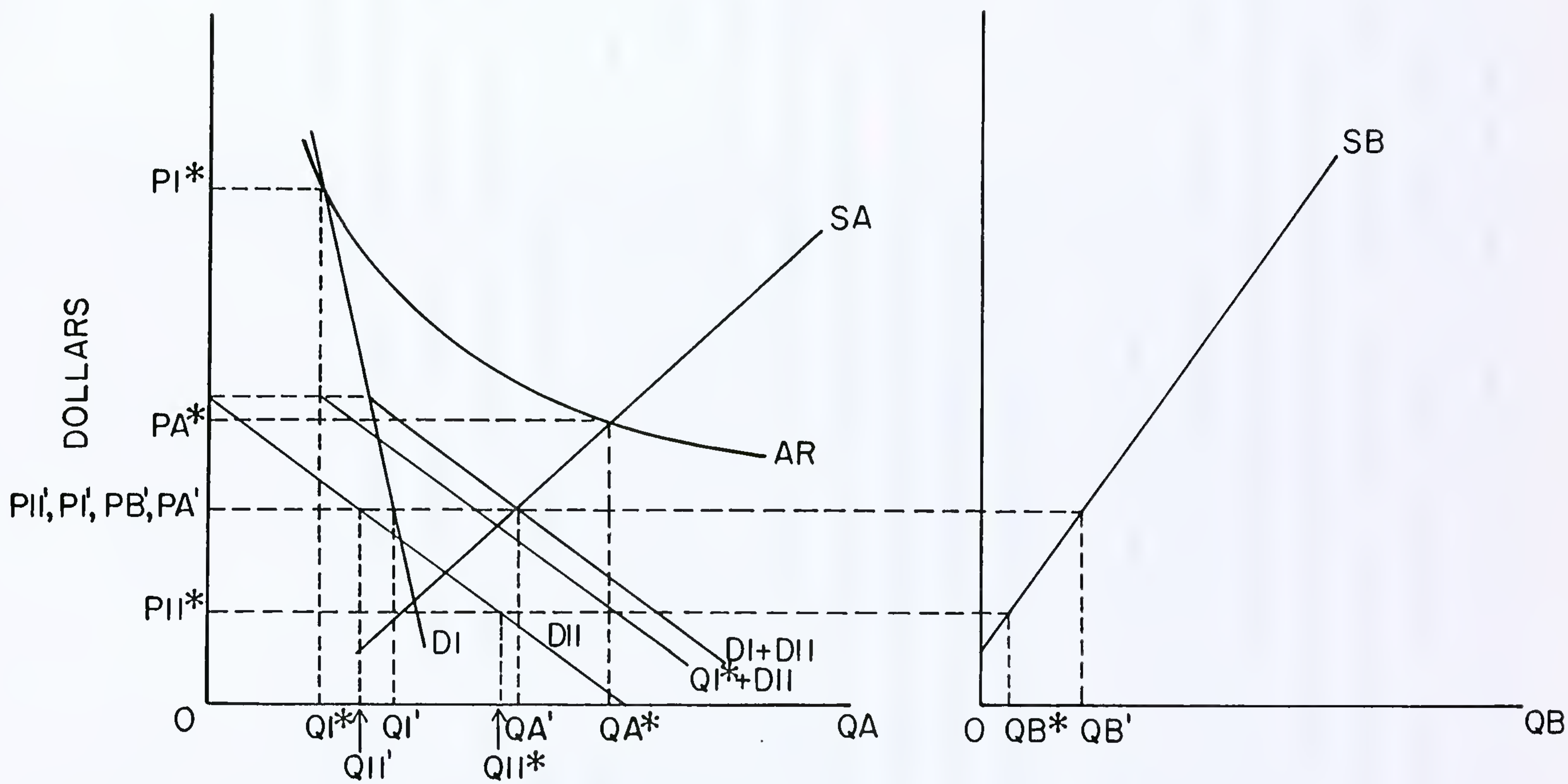


Figure 3. Ippolito-Masson Model of U.S. dairy Industry

The unregulated milk market equilibrium would be established when total demand (DI + DII) equals SA (Figure 3). At that point, PA' and QA' are determined. With PA' = PI', QI' is obtained, and with PA' = PII' = PB', QII' and QB' are, respectively, determined. The total social costs of moving from the unregulated equilibrium to the regulated equilibrium were estimated by the authors to be around $60 million (including $34 million due to government programs administration) [Ippolito and Masson, 1978, p. 60].

Ippolito and Masson [1978] presented two methodological contributions. The first was the modelling of the relationships between the regulated grade A milk market and the unregulated grade B milk production. The second was the adoption of a reasonable assumption with respect to the negative slope of the demand for manufacturing milk (not totally elastic as in Kessel's model). As pointed out by Dahlgran [1980, p. 64], the demand for manufacturing milk could be downward sloping for any quantities demanded above the price support level. Dahlgran also identified one shortcoming on their model: "DII is the demand for manufacturing milk out of grade A supplies while manufacturing demand can also be supplied out of grade B production" [1980, p. 64]. The major consequence is that the price of manufacturing milk happens to be determined by the grade A milk only. This misconception is also present in Dahlgran's model.

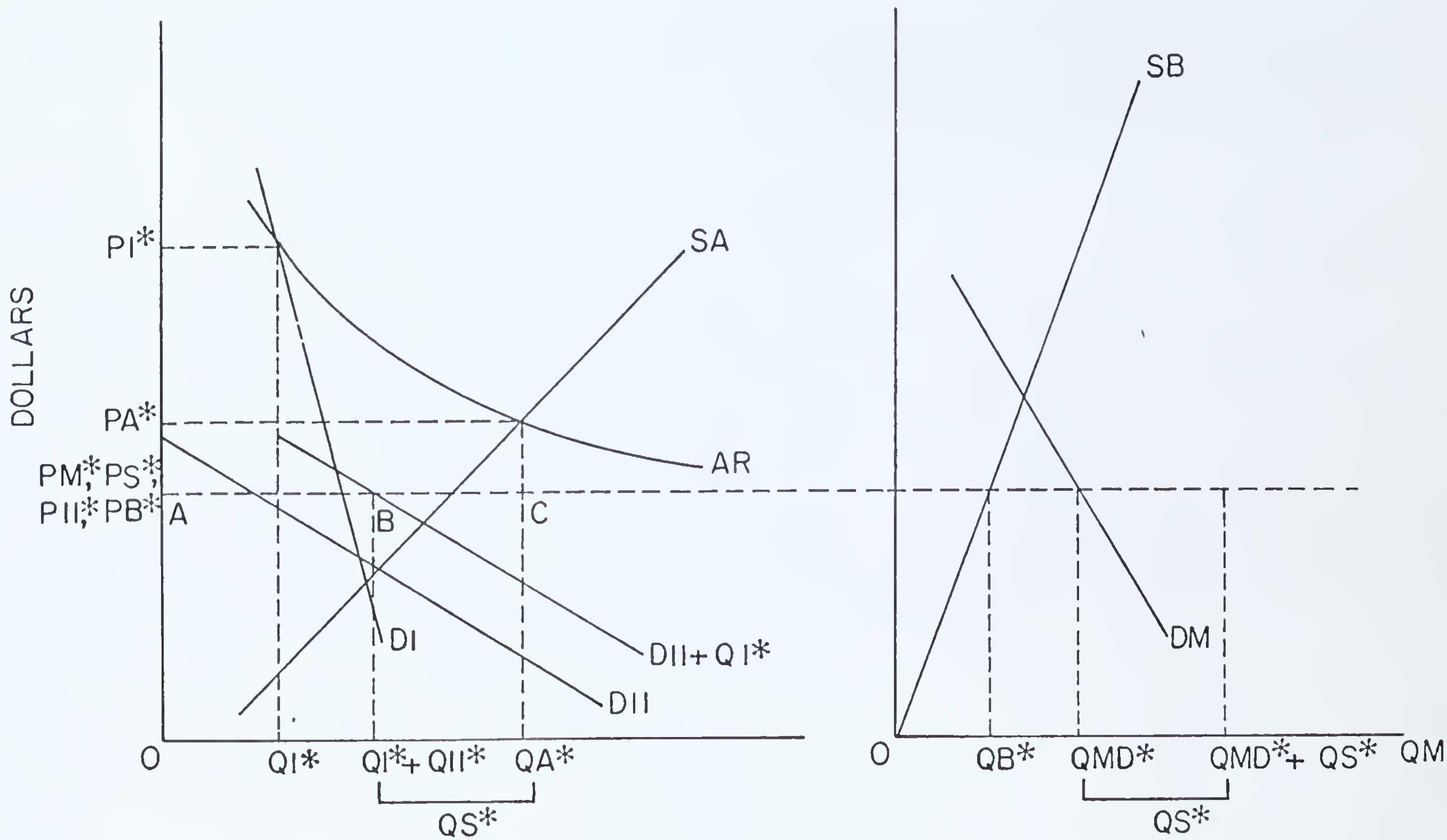
Dahlgran's Model

Dahlgran added significantly to the previous models by incorporating local interdependence between the grade A and grade B milk production, and by including a much needed manufacturing milk demand function, DM, as in Figure 4. Of more importance is Dahlgran's explicit assumption incorporating features of the price support program. Also, instead of using retail demand functions, or demand functions derived from retail levels, as usual, he used a derived demand approach. These concepts when applied to the first handler level permit the observation of both supply and demand points for crude milk.

The functions DI, SA, SB, and AR, are the same as defined in the Ippolito-Masson model. The regulated equilibrium is described in Figure 4. QI^* is the quantity of grade A milk that, according to DI, processors will be willing to buy at the minimum price PI^* fixed by the marketing order administration. At the price support PS^*, both QB^*, QII^* and QS^* are determined. This last variable represents the amount of CCC removals from the grade A market, which is given by QA^* - $(QI^* + DII[PS^*])$. QA^* is determined at the blend price PA^*, calculated as

$$(2.7)\quad PA^* = (PI^* \; QI^* + PS^* \; QII^*)/(QI^* + QII^*).$$

Dahlgran's model for the unregulated market is depicted in Figure 5. "The unregulated equilibrium will exist at a point where fluid demand is satisfied out of grade A production, and manufacturing demand is satisfied out of grade B production, and the grade A-grade B



Panel a: Fluid Milk Market

Panel b: Manufacturing Milk Market

Figure 4. Dahlgran's Regulated Local Dairy Market

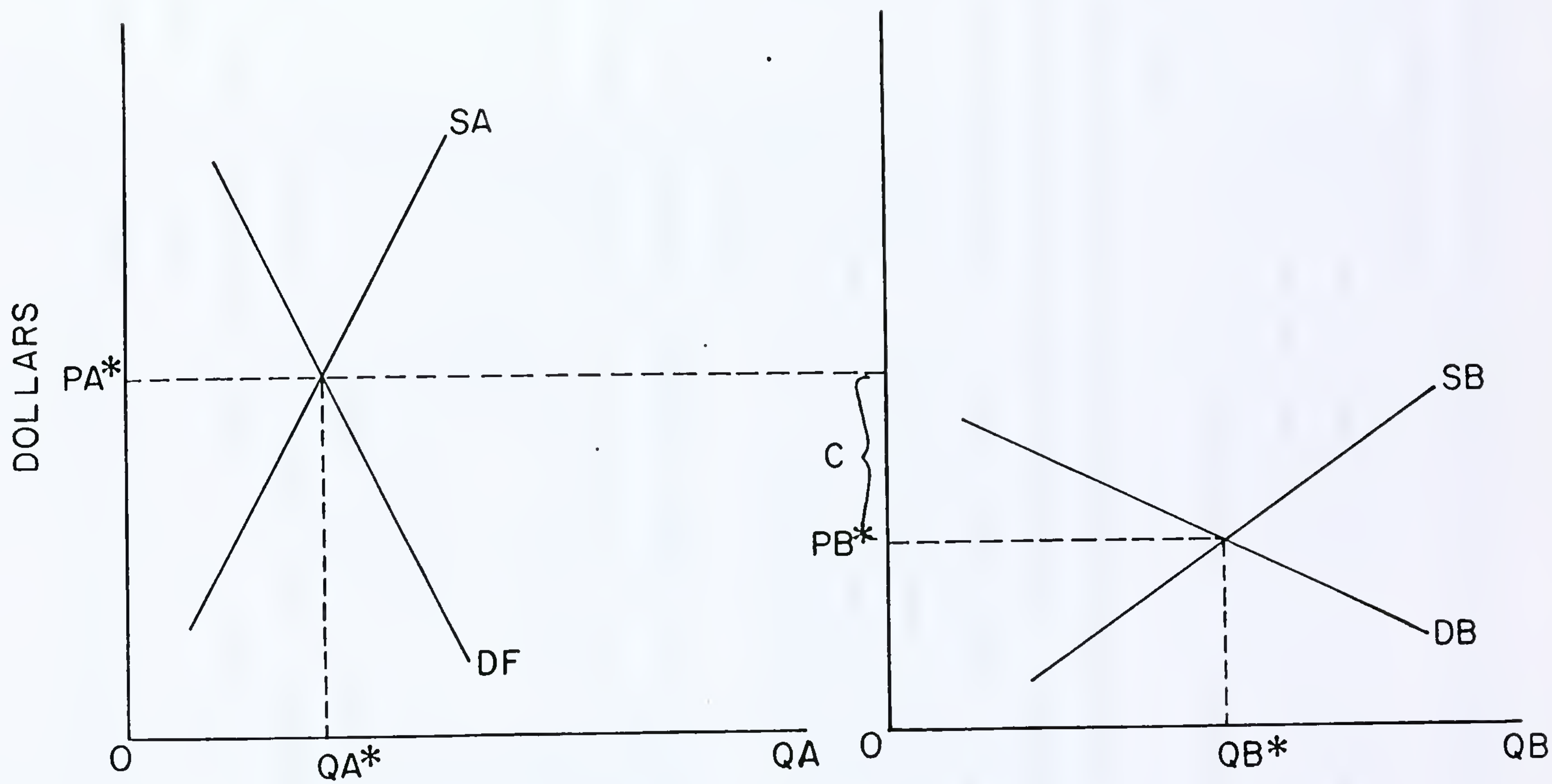


Figure 5. Dahlgran's Model of the Unregulated Dairy Market

price difference is equal to the cost of production difference (C)" [Dahlgran, 1980, pp. 81-82].

Moving from the unregulated equilibrium to the regulated milk market, as in Figure 4, the total social cost to society was estimated at $131 million, including $34 million imputed to the programs administrative costs.

Note that although the models previously reviewed have all been used to estimate the social costs of deregulation, a purpose that differs from the one pursued in this study, they contain the basic structure that could be helpful in constructing a model to simulate alternative coordinating arrangements to reduce the imbalance between supply and demand for manufacturing milk. Some modifications will be needed for correcting shortcomings.

The first shortcoming in Dahlgran [1980] is that the equilibrium price for manufacturing milk, in the absence of the price support program, would be determined in the grade A market only, that is,

$$(2.8) \quad PM^* = PII^* = DII[QA^*],$$

where, PII^* is the price of class II milk, and PM^* is the price of manufacturing grade milk. This approach ignores the participation of the grade B milk production on the supply side of the manufacturing milk market. Besides, with the price supports, the definition,

$$(2.9) \quad QA = QI + QII,$$

is no longer obtained (AB<AC) in the equilibrium solution as it is depicted in Figure 4a.

Also, Dahlgran did not model a decrease in the price support but the disruption of the price support program. Moreover, all government purchases were determined in the grade A market only. The potential effects of grade B milk production were not considered.

It is interesting to note that the empirical determination of the regulated equilibrium values would require the empirical estimation of DII, which was never done by Dahlgran. As a matter of fact, he never estimated the regulated dairy market model. By never estimating it, he did not validate his model. It is a usual procedure that subsequent simulations could conceivably deal with any of a large variety of assumptions only if the model provides a reasonable simulation of the "real" (observed) behavior. All simulation results should be compared with the BASE simulation rather than with actual values. This procedure must be followed in order to separate regulation-induced effects from simulation-induced errors. Only then can the observed differences between regulated (BASE) and nonregulated simulation be attributed to elimination of the government program. Comparisons of unregulated simulated performance with actual performance (as done by Dahlgran) would be confounded by the known inability of the simulation algorithm to reproduce historical behavior exactly even with the regulation in place [Thor and Jesse, 1981, p. 29].

Finally, the incorporation of the effects of the price supports was done by "shifting the manufacturing demand by the amount QS" (CCC removals from the grade A market)[Dahlgran, p. 78]. Such shifts were supposed to be captured by introducing QS as an explanatory variable in

the demand equation for manufacturing milk. By making QS exogeneous the method used becomes inadequate for this study. Here it is necessary to have QS determined by the model.

As a group, the three models reviewed do not consider the vertical coordination as an alternative approach to balance supply and demand for manufacturing milk.

The appropriate modifications to correct for the shortcomings will be described in constructing the model in Chapter III. An assumption will be made to incorporate dairy cooperatives in the exchange of crude milk between producers and processors/manufacturers. These bargaining entities will be assumed to play a coordinating role in the vertical organization of the dairy market.

Price Support Models

The models reviewed so far were chosen because they provide the basic framework for this study. However, they were used for another purpose, which was to measure the costs incurred by society when moving from a hypothesized unregulated market equilibrium to the regulated dairy market. The models that follow are specifically related to the price support program.

The Buxton-Hammond Model

Buxton and Hammond [1974] developed a method of measuring the net social cost at alternative levels of price support under condition of exporting or destroying government purchases and under a condition of domestic redistribution.

According to their model the fluid demand curve DFs and the supply curve for all milk Ss (Figure 6) show the amount of milk demanded as fluid and the total milk supplied, respectively, at each manufacturing milk price with the assumption of a constant fluid-manufacturing price difference. The differential between manufacturing milk price and class I milk prices was set at $2.17, and the constant differential between manufacturing milk and whole milk prices was set at $1.00 [Buxton and Hammond, 1974, p. 287].

When the government sets the price support level for manufacturing milk PS^* (most certainly above its equilibrium price), the milk production will be QW^* (Figure 6). The quantity QF^* will be allocated to the fluid market, QMD^* to the manufacturing market, and $QS^* = QW^* - (QF^* + QMD^*)$ will be removed from the market by government programs. The price received by farmers would be $PS^* + \$1.00$, and fluid milk buyers will pay $PS^* = \$2.17$. The authors, with the above model and using previous estimated elasticities, concluded that the increase in social cost of increasing the support price from 85 to 90 percent of parity would be $107 million [p. 289], and that at 85 percent of parity the estimated annual social costs would decrease from $340 to $65 million if all government purchases were distributed back to the community [p. 290].

The contribution of the Buxton and Hammond model [1974] is the treatment of an integrated (grade A and manufacturing) milk market, in which the price support level is the policy variable. The shortcomings of their model are as follows: (a) The model was not estimated

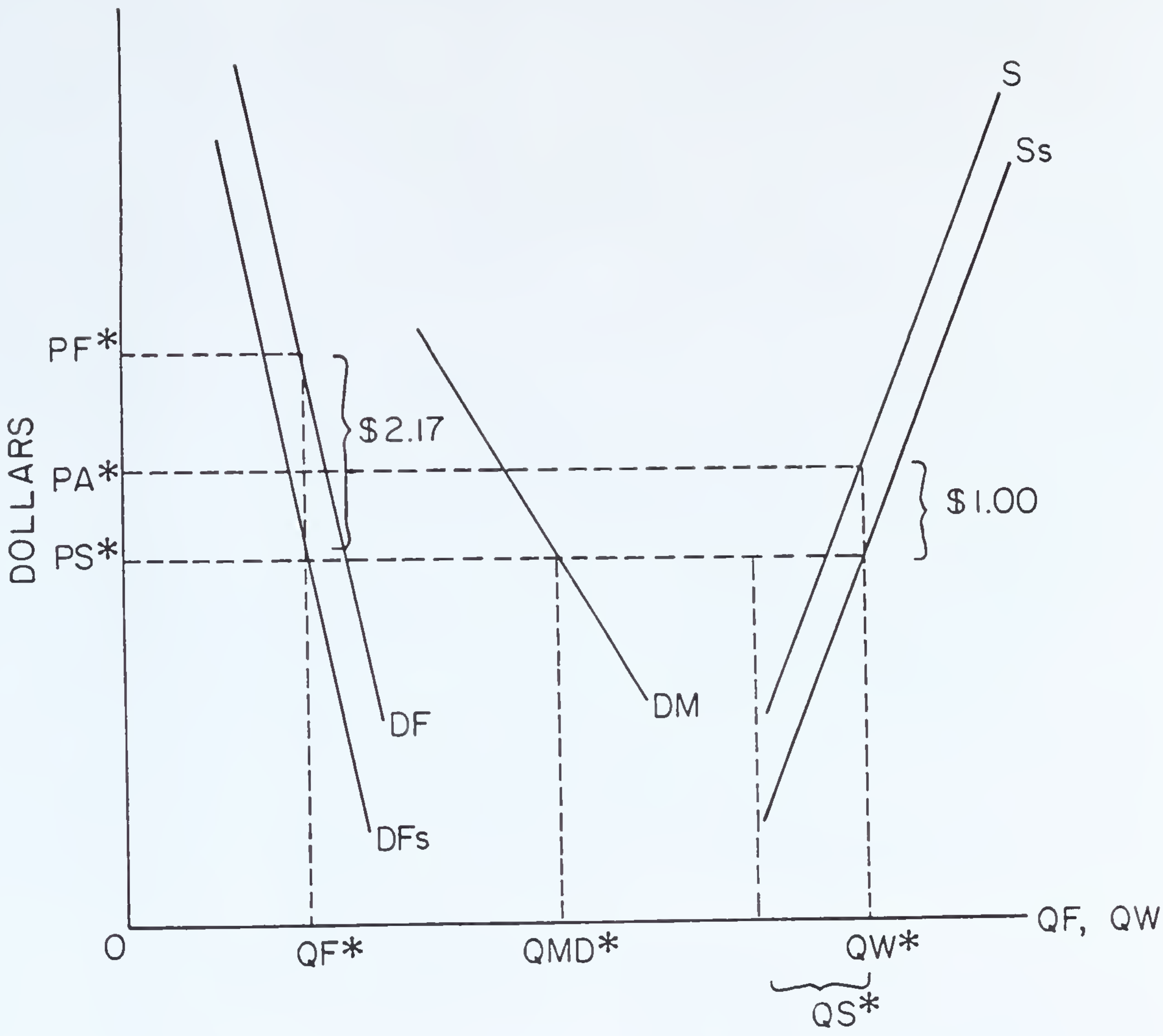


Figure 6. The Buxton-Hammond Model for the Price Support Program

by the authors. Previous estimated elasticities were used. (b) The use of constant differentials between PI and PS, and PW and PS, when the observed differences are not so constant as they seem to be (see Table 1). (c) The supply function S contains both fluid eligible and grade B milk.

The Hein Approach

Hein [1977] specified and estimated an econometric model of the U.S. dairy subsector. The model was used to measure the impacts of milk regulation on consumer prices over the 1949-73 period, and the costs to consumers of the price support and Federal order program. The total annual cost of the Price Support Program was found to be $402 million. The Federal marketing order system was estimated to cost $175 million per year to consumers. Hein's model for the U.S. dairy industry was estimated by OLS using annual data from 1950-69. His model, however, was not built to answer the questions posited for this study.

As a group, the above models do not characterize the price support program as a potential instrument to vertically coordinate the industry crude milk exchanges.

Models for Vertical Coordination

The models by Kessel [1967], Ippolito and Masson [1978], and Dahlgran [1980] were reviewed in the first section because they provide the basic framework to which extensions will be made for obtaining an adequate analytical instrument to examine the problem identified in Chapter I. The models that deal with features of the price support program were reviewed in the second section. In this section, the

Table 1. Selected Milk Price Differentials

	Prices $1.00 cwt.	
	Fluid Differentials (Pf - Pm)	All Milk Differentials (Pw - Pm)
1960	2.23	.96
1961	2.07	.86
1962	2.15	.89
1963	2.10	.89
1964	2.09	.89
1965	2.05	.89
1966	1.85	.84
1967	2.14	.96
1968	2.28	1.02
1969	2.45	1.04
1970	2.24	1.01
1971	2.26	1.01
1972	2.17	1.00

Source: USDA, Dairy Situation, ERS, DS-344, March 1973.

models for coordinating the exchange of agricultural products under price supports are reviewed.

Vertical Coordination through Price Mechanisms

Some subsectors in agriculture have demonstrated their preference for administrative type coordination in part because it leads to a more stable volume moving through the system and a more homogeneous quality of the product [Collins, 1959]. However, even in the administratively coordinated system, the change-inducing role of price is present [Gray, 1964].

Buxton et al. [1981] discuss some alternatives to restore balance between supply and demand and reduce government program costs. The effectiveness of surplus disposal alternatives is descriptively (no model was used) questioned by the authors. The supply side alternatives were called "painful" and most were discarded for difficulties related to their administration and costs. "The only remaining alternative is to lower the level of the support price" [Buxton et al. 1981, p. 4], which is, typically, a proposal to vertically coordinate the subsector through an administered price mechanism. The spirit of this idea is reviewed next.

General model. Gardner [1981, p. 13] illustrates the general model of a price-support program, which is adequate to examine the effects of price-support controls. Consider Figure 7, where S and D are the supply and demand curves for an agricultural commodity under price support program. At any price support above PE the government acquisition of excess

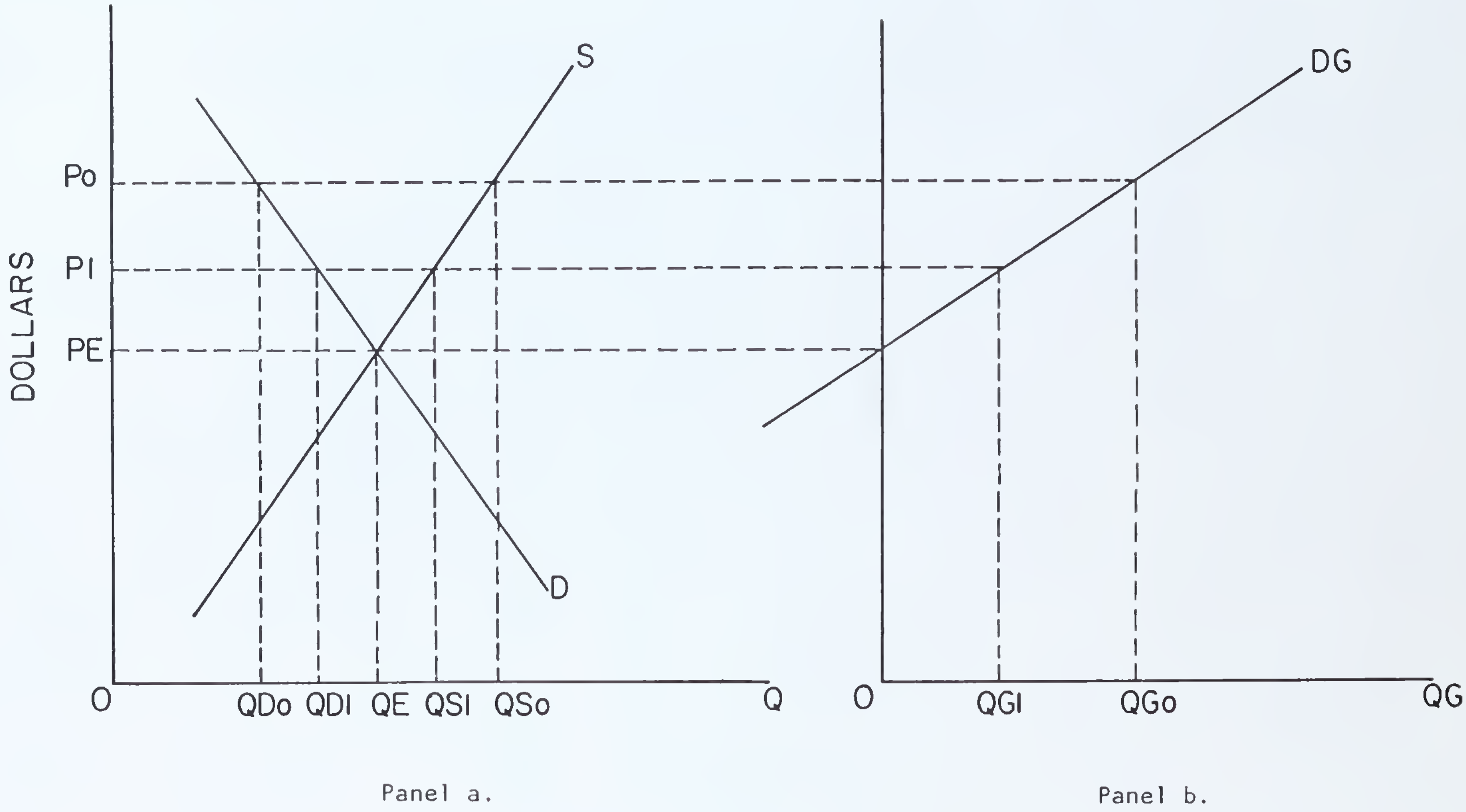


Figure 7. The Effects of Reducing Price-Support Levels

supply is given by (QS - QD). When the support level is reduced from PO to PI, as in Figure 7, production reduction is given by (QSO - QSI), and consumption increases to QDI. Government purchases are reduced from QGO to QGI, as in panel b of Figure 7.

The USDA model. Recently, Salathe, Price, and Gadson [1982] presented the dairy-sector sub-model contained in the U.S. Department of Agriculture's Food and Agricultural Policy Simulator (FAPSIM). Among other things, the model can be used to estimate USDA purchases of manufactured dairy products and the costs of government dairy product purchases under alternative dairy price-support options. The authors used the model to explore the effects of lowering the price-support level on dairy products from 75 to 65 percent of parity.

The dairy submodel consists of four components: (a) milk supply; (b) milk price; (c) milk manufacturing, and (d) commercial demand for dairy products. Ordinary least squares was used to estimate its equation parameters. The results suggested that the farm price of milk would fall by about $0.11 per cwt. in 1981, $0.83 per cwt. in 1982, and $1.26 per cwt. in 1983. USDA outlays for purchasing butter, cheese, and nonfat dry milk were estimated to fall $870 million in 1983. Cash receipt to dairy farmers were estimated to fall by $1.8 million in 1983 [p. 11]. Total milk production would be about 3.0 billion pounds lower in 1985 [p. 14].

The USDA's FAPSIM seems to recognize the price support program as a mechanism for coordinating the dairy subsector, and first operates with the concept of commercial demand for manufacturing milk.

The shortcomings refer to its annual formulation. Since 1973 the price support has been readjusted twice in a year. The change in the regime might have caused a change in the industry behavior. The use of annual data would aggregate such effects. Also, adjustments in production due to a price variation may take place in periods shorter than a year.

Boynton and McBride model. This model [Boynton and McBride, 1980a] differs from the other models because of its embodied farm level details, and because it does not illustrate the effects of their plan on the entire subsector. The recommended plan is an extension to the blend price plan with no production base component and to the base-excess plan with a production base scheme.

Figure 8 depicts the situation for a producer under the proposed plan. Boynton and McBride assumed that the producer, delivering milk to a market order, has an IBASE (class I base) of four units and a RESBASE (reserve base) of one unit. A quantity of five units would be produced [1980a, p. 6]. The producer's marginal revenue function would be composed of three linear segments, which would improve the information carried by the pricing system. Any milk produced by the farmer in excess of IBASE plus RESBASE would be surplus milk. Surplus milk is priced below the lowest class price in the order. The capability to discourage surplus production would be enhanced over the other two common Federal marketing order producer payment plans.

Boynton and McBride assumed that dairy cooperative managers recognize the effect of surpluses on milk prices, disposal costs, and even

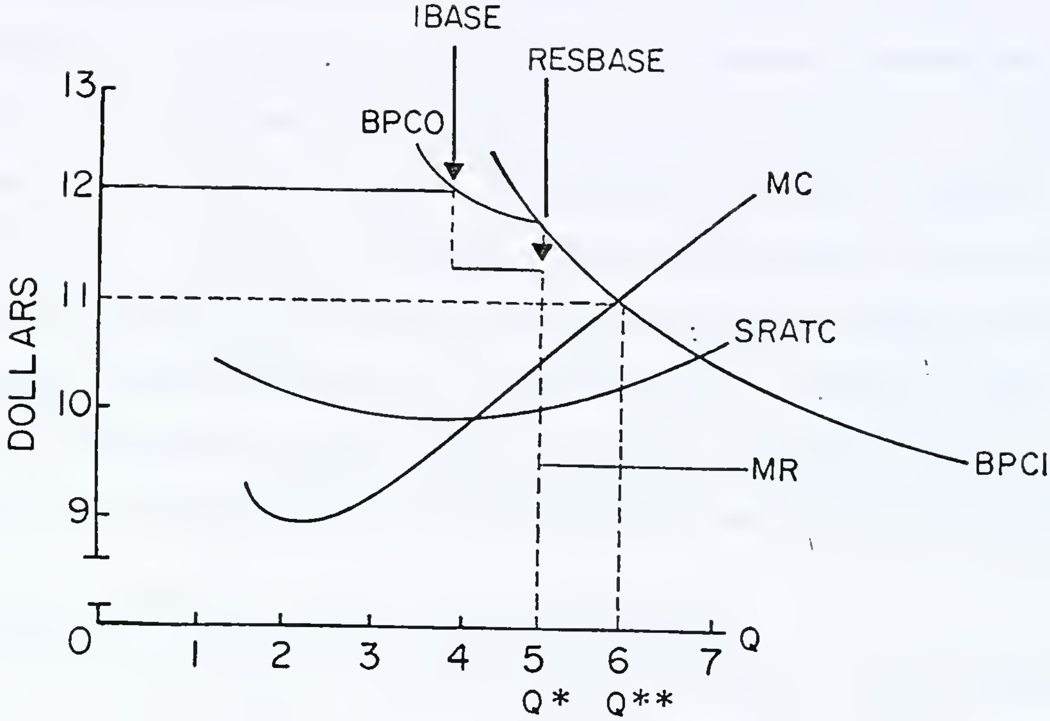


Figure 8. Boynton-McBride Plan

on the viability of the price support program [1980a, p. 3]. The important cooperative coordinating role would be to "pass on market information to keep the members informed. If more aware of market conditions, members may make production decisions more consistent with the overall supply-demand environment" [1980a, p. 4].

The difficulty with their plan is that it requires a perfect and constant update of information not generally available in the market, like farmers cost structures. Furthermore, the economic assumption of profit maximization would be critical for the plan's success. If farmers behave as if to maximize revenue, the plan would not work. However, in the current regulated environment, the relevant marginal revenue for the typical farmer is not given by the three horizontal segments, but by a weighted average revenue curve (AR1) (Figure 8). Accordingly, the farmer represented in Figure 8 would be willing to produce Q^{**} and receive an average weighted price of $11.00 for each unit of the product.

Vertical Coordination through Nonprice Mechanisms

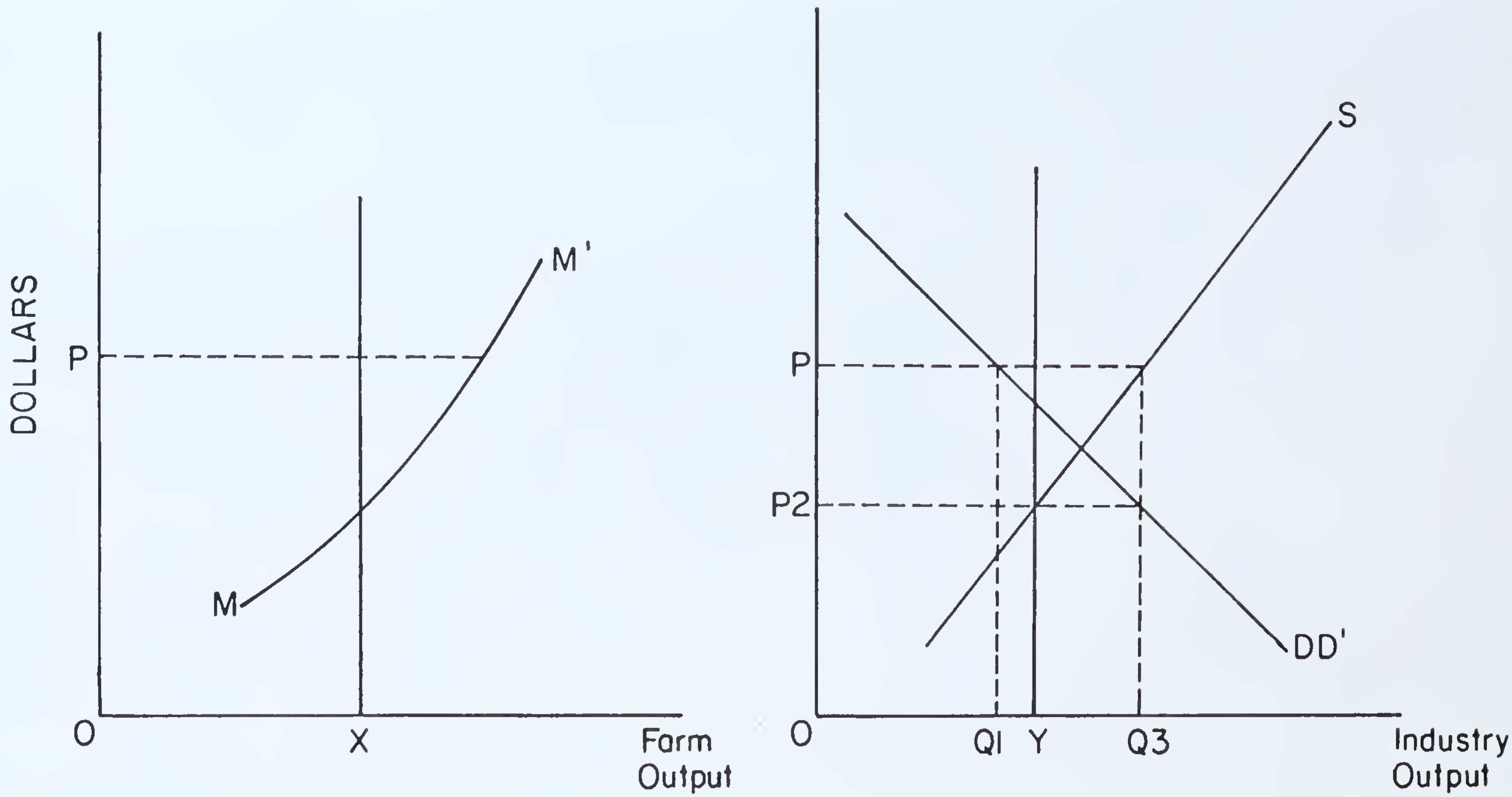
Coordination between exchange partners sometimes is made through voluntary agreements that differ from a price guided solution, or through the use of authority. Production control or marketing allotments on U.S. milk producers have never been required [Hammond, 1981, p. 8]. If administrative difficulties (quota establishment, new entrant quota, input controls, among others) were ignored, the effects of these

production control measures can be illustrated. Some proposals used for other agricultural commodities will be reviewed in this section. The illustrations are taken from Mansfield [1979] and Gardner [1981].

Quotas. This scheme specifies that each farm can produce a certain quota, 0X, as in panel a of Figure 9. The total quota for the entire industry is 0Y (panel b of Figure 9). At the support price 0P, consumers will purchase 0Q1, according to their demand schedule DD'. The government will buy (0Y - 0Q1) units of the product. In contrast to the situation that would prevail without the quotas, the government would have to purchase additional output (0Q3 - 0Y) to guarantee the price 0P to producers.

Deficiency payments. In 1973, a plan earlier proposed by President Harry Truman's Secretary of Agriculture, Charles Brannan, and President Dwight Eisenhower's Secretary, Ezra Taft Benson, was adopted. An illustration of this plan is provided in Figure 9. Suppose that the government guarantees each farmer a price 0P, as in Figure 9, panel b. At the guaranteed price farmers produce 0Q3 units of the product. The market will value each unit of the product by only 0P2. The government then issues subsidy checks to farmers to cover the difference between the price they received, 0P2, and the guaranteed target price 0P. Compared to the situation that would prevail when the government buys (0Q3 - 0Q1) and stocks the volume purchased, the government costs are reduced by (0P - 0P2) (0Q3 - 0Q1).

The alternatives described above have never been the subject of investigation through a simulating model in the dairy industry.



Panel a.

Panel b.

Figure 9. Price Support with Production Control

Demand and Supply Functions for Milk in the United States

The policy models reviewed consistently contain supply and demand functions of milk and dairy products. The policy model that will be developed and estimated for this study will also include demand and supply functions. A review of recent empirical estimations of these functions for the U.S. will follow next.

Demand Models

Derived demand functions for fluid and manufacturing milk at the farm level was estimated by Rojko [1957], Wilson and Thompson [1967], George and King [1971], Prato [1973], Hallberg and Fallert [1976], and Dahlgran [1980]. (See Table 2). Regrettably, these studies obtained estimates that are somewhat inadequate for this study. The reasons are as follows:

(a) All but Dahlgran's [1980] estimations are derived from the demand for dairy products at retail level. The difficulty is that such displacements require the formulation of a marketing margin model that, if not correctly specified, causes distortions on the correspondent derivations. This procedure is judged unsatisfactory.

(b) Furthermore, Dahlgran's criticisms were somewhat convincing that further work was needed in this area. He reported that the models by Wilson and Thompson [1967], Prato [1973] and Hallberg and Fallert [1976] "have scant if any theoretical development" and "are econometrically weak," and that the identification of retail products in terms of the farm products are frequently very difficult [1980, p. 51].

Table 2. Estimated Demand Functions for Dairy Products

Author	Market(s) of Reference	Farm Level	Retail Level
Boehm, W.T. (1975)	U.S.		x
	U.S. Southern		x
Brandow, G.E. (1962)	U.S.	x[a]	x
Dahlgran, R.D. (1980)	Chicago Regional[b]	x	
	New York-New Jersey	x	
	Middle Atlantic	x	
	Upper Midwest	x	
	New England	x	
	Southern Michigan	x	
	Eastern Ohio, W. Penns.	x	
	Texas	x	
	Ohio Valley	x	
	North Carolina	x	
	Oklahoma Metrop.	x	
	Nashville	x	
	Quad Cities, Dubuque	x	
	Nevada	x	
George & King (1971)	U.S.	x[a]	x
Hallberg & Fallert (1976)	U.S.	x[a]	x
Hein (1977)	U.S.		x
Kwoka (1977)	U.S.		x
Prato (1973)	U.S.		x
Rojko (1957)	U.S.	x[a]	x
Wilson & Thompson (1967)	U.S.	x[a]	x

[a]Via displacement from retail level.

[b]Market orders.

For the reasons pointed above, Dahlgran's estimation procedures will be reviewed with more detail.

Dahlgran's assumption of subsector analysis [Dahlgran 1981, p. 105], or the representative agent implies perfect substitution between grade B and grade A milk. This input substitution is not permitted in the fluid milk processing plant.

Using that assumption, he derived and estimated fourteen sets of derived demand price elasticities. Each set refers to one of the following marketing orders: New York-New Jersey, Chicago Regional, New England, Middle Atlantic, Eastern Ohio-Western Pennsylvania, Upper Midwest, Southern Michigan, Ohio Valley, Texas, Nashville, North Carolina, Quad Cities-Dubuque, Oklahoma Metropolitan, and Nevada. These marketing orders were selected by a sampling procedure specifically designed to reduce the number of markets to be investigated.

The elasticities for the markets not directly estimated would be calculated by using a model suggested by Searle [1971, p. 90-91], which is based on the stratum characteristics of each non-sampled market, and on the estimated stratum parameters obtained from the sampled markets. The Oregon, New Jersey, and Massachusetts state orders were combined with nearby federal order markets and the Hawaii state order was considered outside the scope of his study.

A milk manufacturing center was assumed to correspond with each fluid consumption center. The production areas were defined to correspond geographically to the continental United States.

However, after testing and rejecting the hypothesis that regional or size effects have affected his estimated elasticities, he proposed that the elasticities for any non-sampled market could be calculated by averaging the sampled markets estimated elasticities. Next Dahlgran passed the supply and demand functions through the average quantities and prices for the following regions: Northeast, Mid-Atlantic, Southeast, Lake States, Corn Belt, South Central, North Plains, Central Plains, South Plains, North Rockies, Central Rockies, Northwest, and California. The formulation used was

$$(2.10) \quad Q = aP^{b}$$

where

Q is the average quantity of milk,

P is the average price of milk,

b is the estimated average elasticity, and

a is the implied constant term, so that the above equation is satisfied for the 1976 average price and quantities of the respective market.

After Dahlgran [1980] concluded that "all markets have the same set of structural parameters" [p. 188], the responses of the industry participants to price variations in any geographical aggregation of dairy markets in U.S. could then be measured through the estimated average elasticity.

However, Dahlgran [1980] provided the only study estimating a consistent set of derived demand functions for processors and manufacturers. His demand elasticities estimates are reported in Table 3.

Table 3. Summarization of Dahlgran's Estimated Policy Elasticities

Market[a]	% US Total Del.	Demand Elasticities				Supply Elasticities			
		Fluid Milk		Manufacturing Milk		Grade A. wrt.		Grade B wrt.	
		PF	Std. err.	PM	Std. err.	PA	PB	PA	PB
Chicago Regional	10.7	-0.0792	0.0416	-0.123	0.121	4.87	-4.01	-1.86	1.87
New York, New Jersey	10.4	-0.0590	0.0725	-0.364	0.151	-0.0269	0.000	--	--
Middle Atlantic	5.9	-0.168	0.0193	-0.646	0.228	0.770	-0.0532	-0.597	0.657
Upper Midwest	5.9	-0.194	0.109	-0.0933	0.100	4.74	0.000	0.000	-2.50
New England	5.5	-0.109	0.0574	-0.286	0.417	2.48	0.000	--	--
Southern Michigan	4.4	-0.0919	0.0416	-0.682	0.172	0.339	0.000	0.000	-0.654
Eastern Ohio, W. PA	3.8	-0.184	0.0447	-0.252	0.216	0.517	-0.0636	-0.656	1.02
Texas	3.8	-0.166	0.119	0.942	0.478	3.61	0.000	--	--
Ohio Valley	3.3	-0.183	0.0906	-0.485	0.182	0.770	-0.223	-0.776	0.778
North Carolina (state)	1.6	-0.508	0.0448	0.674	0.359	-0.000	0.000	--	--
Oklahoma Metropolitan	0.9	-0.436	0.148	-0.561	0.570	2.02	-0.642	-1.63	1.05
Nashville	0.7	0.0195	0.140	0.136	0.258	1.00	0.000	0.000	0.639
Quad Cities, Dubuque	0.4	0.509	0.529	-0.130	0.130	1.23	-0.723	-1.35	0.269
Nevada (state)	0.1	0.0541	0.112	-0.248	0.468	0.237	0.000	--	--

[a]All markets are federal order markets unless otherwise specified.

Note that five markets (Texas, North Carolina, Nashville, Quad Cities - Dubuque, and Nevada) have unacceptable signs. Besides, the elasticities obtained tend to be highly inelastic.

Supply Models for the Dairy Industry

U.S. dairy farmers' output decisions are hypothesized to depend on the milk prices. This economic sensibility has long been measured and tested for various levels of geographical and time aggregations, under different approaches and methods. Direct estimation of milk supply response functions has been done by Brandow [1953], Halvorson [1955, 1958], Cochrane [1958], Wipf and Houck [1967], Chen, Courtney, and Schmitz [1972], Hammond [1974], Novakovic and Thompson [1977], Houck [1977], and Dahlgran [1980]. Dahlgran estimated a consistent set of supply functions for grade A and grade B milk at the regional level. His models will be examined in more detail.

In 1980, Dahlgran, assuming a representative dairy farm (a farm producing both grade A and grade B milk), derived supply functions from the farmer profit maximization objective function. Results from that derivation adequately capture the phenomenon of conversion from grade B to grade A milk production. However, the "quid pro quo" is that grade A farms would also reconvert to grade B production (following the condition for symmetry), which is a very dubious action to be taken by grade A milk farmers. In fact, additional investments are required in the infrastructure for producing fluid eligible milk.

Dahlgran did not fully account for the advantages of lagged models in the supply functions. The biological nature of milk production may preclude rapid adjustments of output to changes in prices. Lagged model approaches are discussed in the next section.

Price Lagged Models

Supply functions. The biological nature of the underlying milk production process suggests a lagged response of production to a price change. Two difficulties have been common to almost all estimations of milk supply functions with lagged prices: (a) lack of theoretical reference about the intensity across time which farmers can adjust production of milk in response to price variations (the nature of the lagged structure); and (b) lack of theoretical reference indicating the appropriate length of the lags.

Supply functions with lag structures for the milk subsector have been estimated assuming that the greatest increase is forthcoming in the first period with declining increases through time. The partial adjustment model as in Nerlove and Addison [1958] is adequate for this assumption. It imposes a geometrically declining lag structure to the coefficients of the lagged prices.

This expected behavior of the coefficients of the lagged prices has been rejected by Chen, Courtney, and Schmitz [1972] and Milligan [1978]. The argument is that output response to some given price change first increases through time, then decreases. In such a case, only a

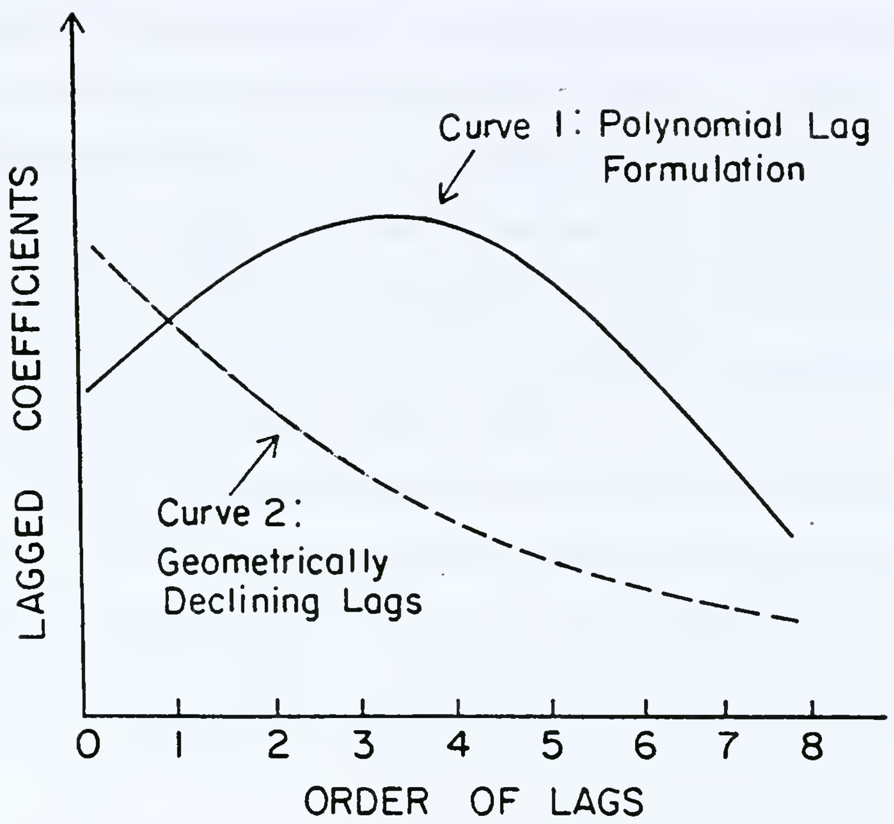
flexible lag structure like the polynomial lag formulation is appropriate. These two structures can be seen in Figure 10 which depicts the assumption above mentioned.

The reasons favoring the polynomial lag formulation are that it allows a greater degree of flexibility in the lag structure, which in turn may improve supply response estimates. However, none of the justifications backing the two structures clearly indicate why the coefficients should behave as delineated by Curve 1, or by Curve 2.

The fact that some adjustments can be made in a short period of time (changing feeding practices and/or culling herds), while others require more time (raising calves), adds nothing to the cause of the polynomial lag formulation. The information that "given a price change," some output response is realized in the short-run and in the long-run is suitable for both the partial adjustment and the polynomial lag models.

Milligan [1978, p. 159] indicates that the nature of his lagged structure model is due to the belief that "some producers result in a weak aggregate short-run response that may even be the opposite of what an economist would expect." Consequently, most of the response to profitability (he did not use prices) could be in the third and fourth lagged years.

Very little has been said about what happens in between the short- and the long-run effects. At any period t, new milk cows are being introduced into the herd. It is not clear that a declining response occurs through time, as is suggested by the Nerlovian partial adjustment model, or that the intensity of responses will first increase, then decrease.


Curve 1: Polynomial Lag Formulation
Curve 2: Geometrically Declining Lags
LAGGED COEFFICIENTS
0
1
2
3
4
5
6
7
8
ORDER OF LAGS

In summary, a large set of patterns are possible. A pre-choice of the nature of the lagged structure is inappropriate since it is sensitive to the specifics of the sampled data.

This kind of "open guard" in the theoretical approach of the lag problems led Levins to postulate that "the compromises inherent in specifying a priori patterns for lagged price parameters can be avoided if the parameters are estimated directly" [1982, p. 286]. The short-run and long-run effects of a price change on milk production would be relatively strong compared to the intermediate term "because short-run changes had already been made and the effects of long-run changes were not yet felt. After the long-run effects the increases in production would become negligible" [Levins, 1982, p. 286].

Although the explanations given are not very convincing ones--primarily in regard to the "intermediate term"--the model run for Mississippi generated a pattern quite similar to the one expected by Levins [1982]. The question that remains is whether Levin's results were due to the sample used (Mississippi data) or whether the pattern found is conceptually sound.

With respect to econometric problems, both partial adjustment and polynomial lag models reduce the number of parameters to be estimated. However, when the sample is large, losses in degrees of freedom is not a problem. What remains important for this research are indications that the "direct approach" could be followed because there will be sufficient degrees of freedom.

Demand models. The uncertainties related to the length and nature of the lag structure are more critical on the demand side, in which the biological characteristics of the milk production do not apply. In cases where theory and/or observation suggest a distributed lag relationship between two time series (Xt and Yt), but the exact specifics of the relationship are rarely known, a data oriented analysis can be adopted to allow the data itself to reveal the approximate length of the lag relationship.

Three alternative procedures exist that could be used in this approach: (a) a cross-correlation technique suggested by Haugh [1972, 1976] and Pierce [1977], (b) a one-sided distributed lag approach implied by Granger [1969] and formalized by Sargeant [1976] and (c) a two-sided distributed lag method advanced by Sims [1972].

The robustness of substantive economic results of all three alternatives was examined by Feige and Pearce [1979]. Studying the relationship between money and income they found that the "Sims procedure yields substantive results quite different from those uncovered by use of the Haugh-Pierce procedure or the Granger procedure" [p. 532]. That is, the nature of an economic conclusion depends on the arbitrary choice of the test to which "the model must first pass in order for the estimation and interpretation of the model to be meaningful" [Feige and Pearce, 1979, p. 521], which does not make sense. Given that the actual state of art in this case is still not set, the above procedures will not be followed.

Since little help could be found in the literature, a search procedure should be used in which the length of the lag is extended until the contribution of the additional lagged price to the regression sum of squares is no longer statistically significant. If the lagged prices were found to be highly correlated, the alternative is to choose that length of the lag which results in the highest value for the coefficient of determination corrected for the number of degrees of freedom. If the differences in that coefficient were found to be so small that a choice is inappropriate, the expected signs of the various coefficients may help in choosing the "best" lag for the problem.

Summary

The model that will be described in the next chapter is built upon, or takes advantage of, the studies reviewed in this chapter. Some modifications are made to include needed detail or to overcome some shortcomings. These shortcomings are discussed below.

Coordinating Issues

The coordinating issues are as follows:

(a) The studies by Kessel [1967] and Ippolito and Masson [1978] do not include the entire manufacturing milk market and do not explicitly analyze features related to the price support program.

(b) The study by Dahlgran [1980] did not consider the price support program as a potential coordinating element in the exchange of crude milk.

(c) The models by Buxton and Hammond [1974] and Hein [1977] could be used to study the possibilities of vertical coordination through the price supports control. However, they were never used for this purpose. Besides, the Buxton-Hammond model does not consider the pooling provisions and does not differentiate supply of grade A from grade B. Its price relationship assumptions seem to be empirically weak across time.

(d) The USDA's FAPSIM [Salathe, Price and Gadson, 1982] does recognize the price support control as a potential element in the subsector coordination. But that model did not contemplate non-price alternatives. Besides, the period of time used (year) is inappropriate for this study.

(e) The Boynton and McBride Plan [1980a] only specifies coordination at the production unit, and it did not consider the effects of the price support program. However, it did recognize the presence of cooperatives in the exchange function of crude milk.

(f) As a group, these studies analyze only problems related to drastic changes in the regulated structure of the subsector.

(g) Finally, these models have not totally explored the blend price curve as a potential price coordinating device.

Empirical Issues

The empirical issues are as follows:

(a) The functions for fluid and manufacturing crude milk at the farm level derived from demand functions estimated at the retail level increase the risk of misspecification. Besides, the identification of retail products in terms of the farm products is frequently very difficult.

(b) The symmetry conditions imposed on the price coefficients of the supply functions for grade A and grade B milk seem to be unreal.

(c) The inclusion of retail level explanatory variables is a procedure regularly used in estimating farm level functions. Although their inclusion is no theoretically required, they may help in correcting for model misspecifications with respect to the choice of the correct time response period.

(d) The concept of a commercial demand for manufacturing milk used in the USDA's FAPSIM [Salathe, Price, and Gadson, 1982] turned out to be an important idea to this study.

Conclusions

In Chapter II, the recent dairy literature was reviewed to search for a conceptual model that, if empirically estimated, would respond to the concerns explicitly described in Chapter I. In reviewing those previous works, it was concluded that very little would have to be done with respect to the conceptual model construction. Basically, the main idea is generated in Kessel's model. Ippolito and Masson, and Dahlgran's contributions were also valuable. Changes were made in the definition of the dependent variable in the manufacturing demand function by including a version of the manufacturing milk commercial demand concept used in the FAPSIM [Salathe, Price, and Gadson, 1982], by excluding the demand for Class 2 milk from those models, and the redefinition of their purpose, scope and equilibrium conditions. It was also concluded that a

complete and coherent set of supply and demand functions would have to be estimated to make the model empirically manageable.

With respect to the supply side it seems that a lagged structure is appropriate for estimating the supply functions of milk. The biological characteristic of the milk production also helps in defining the length of the lag and the length of the time period. The time between short-run adjustments in the farmers' production function and the correspondent variation in output is certainly longer than a month. It is reasonable to suppose that it takes place within a quarter or within a year. Long-run responses of milk production to price variation are likely to occur in periods up to two or three years. Finally, good empirical adjustments of milk output to lagged prices have been obtained [Tomek and Robinson, 1977, p. 352], which is a very desirable characteristic for this study.

No strong reasons were found for specifying the derived demand functions in lagged structure.

Overview

In Chapter III, the models discussed in this chapter will be modified in order to construct a model in which the concerns about vertical coordination and U.S. milk surpluses can be answered. The estimation of the model is discussed in Chapter IV. The simulations of alternative coordinating mechanisms based on the premise that the regulated dairy subsector is an unchangeable reality are made in Chapter V.

CHAPTER III
VERTICAL COORDINATION IN THE UNITED STATES DAIRY INDUSTRY

Introduction

The difficulties in using the current policy models to assess the vertical coordination in the U.S. dairy industry were identified in Chapter II. The difficulties were either shortcomings characterized by lack of needed details, by deficiencies in analyzing the available instruments of coordination, or by imperfections in their estimation procedures. The conceptual model for the dairy industry that will be developed in this chapter is built upon the basic structure of the models reviewed. Some modifications are introduced to overcome the referred shortcomings in order that the vertical coordination among dairy farmers, dairy cooperatives, processors of fluid milk, and manufacturers of dairy products could be adequately considered. This model will be empirically estimated and utilized to simulate the impact of alternative exchange arragnements on the balance between supply and demand of crude milk in the U.S. dairy industry.

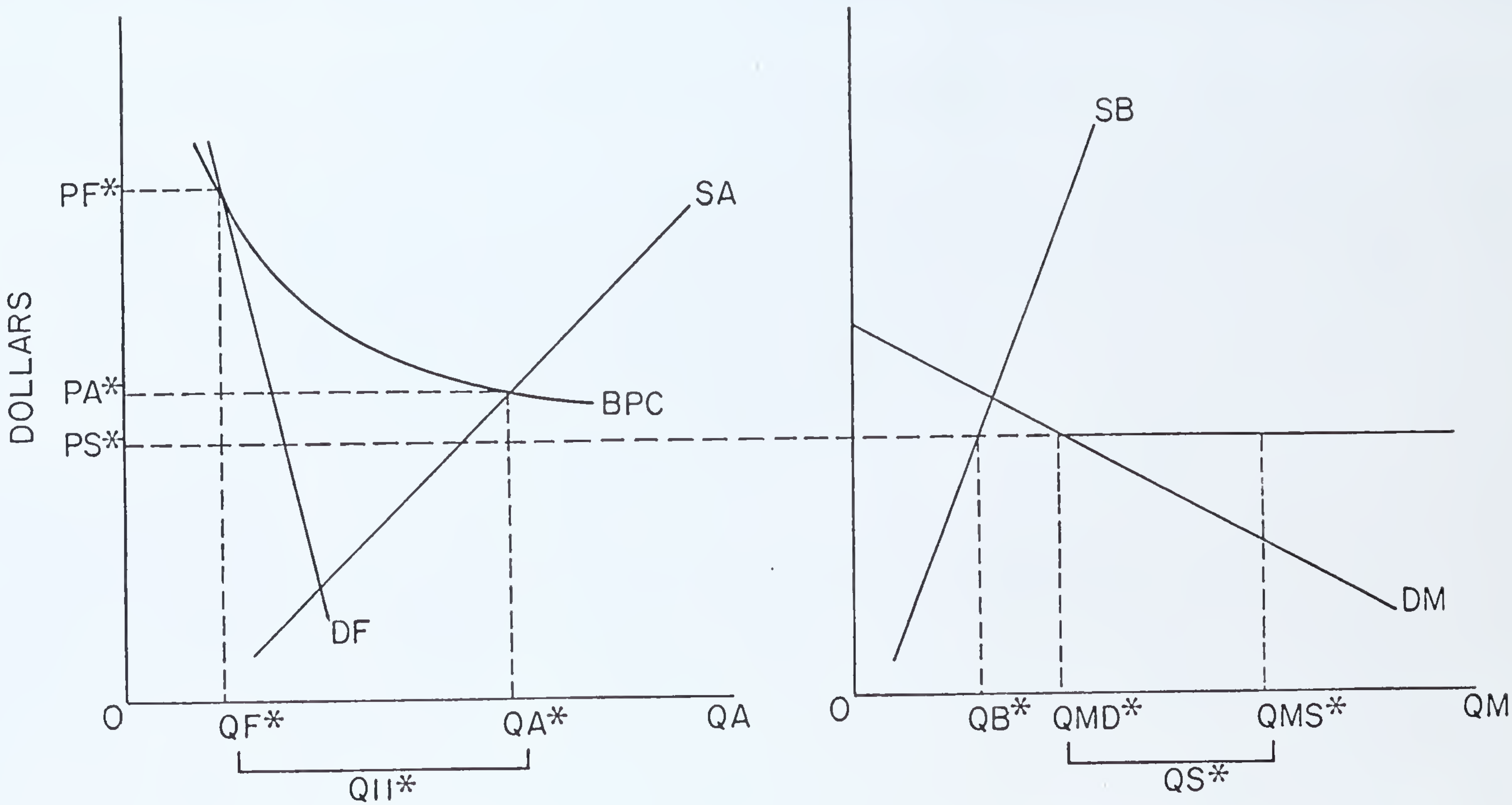
A Model for the Crude Milk Exchange

The model formulated in this section explains the regulated equilibrium for crude milk exchange between producers and processors/

manufacturers (first users). The model is first graphically demonstrated, then it is mathematically developed.

Graphical Framework

Figure 11 depicts the market equilibrium for crude milk in period t. The price for fluid milk is $PF^* = PI^* + PR^*$, where PI^* is the minimum class I milk price established by the Federal Marketing Order system, and PR^* is the cooperatives' announced over order class I price. Given the derived demand for fluid milk, DF(PF), the quantity QF^* is determined. In Figure 11 PS^* is the equivalent manufacturing milk price supported above the market equilibrium price by government. At PS^*, QB^* is produced by grade B milk farmers. Given derived demand for manufacturing crude milk, DM, QMD^* will be acquired by the manufacturers to meet the dairy products' commercial outlets. The blended price for grade A milk, when PF^*, QF^*, and PS^* are given, becomes a function of the volume of grade A milk placed in the manufacturing market, QII^*. As $QF^* + QII^* = QA^*$, PA^* is also a function of the total volume produced. Grade A farmer's optimum volume of production is determined when the blended price curve BPC, intercepts SA, the supply function of grade A milk. The volume of manufacturing milk available in the market, QMS^*, is thus given by $QII^* + QB^*$. All of it is bought by manufacturers, but part of it is not sold to commercial users. The government purchases of equivalent manufacturing milk in period t, QS^*, is given by the difference between QMS^* and QMD^*.



Panel a. Fluid Milk Market

Panel b. Manufacturing Milk Market

Figure 11. Model for the U.S. Regulated Dairy Market

The diagram on Figure 12 shows stepwise how the equilibrium solution values can be achieved with the above model. The endogenous variables in the model are PA, QA, QF, QII, QMD, QS, QB, QMS, PF, PM, and PB. Exogenous variables are PIt, PRt, PSt.

Mathematical Framework

The model described graphically in the last section can be formulated in terms of mathematics. It is composed of four behavioral equations plus price and quantity identities. The behavioral equations do not include all the explanatory variables for expository convenience only. These variab les will be properly discussed later.

Supply and demand relations.

(3.1) QFt = DF(PFt), derived demand for grade A milk by processors.

(3.2) QMDt = DM(PMt), derived demand for manufacturing milk by manufacturers.

(3.3) QAt = SA(PAt), supply of grade A milk by farmers.

(3.4) QBt = SB(PBt), supply of grade B milk by farmers.

Quantity conditions.

(3.5) QIIt $\equiv$ QAt - QFt, all grade A milk is used in processing fluid milk products or in the manufacturing of dairy products.

(3.6) QSt + QMDt $\equiv$ QMSt, total demand for manufacturing milk equals its available supply.

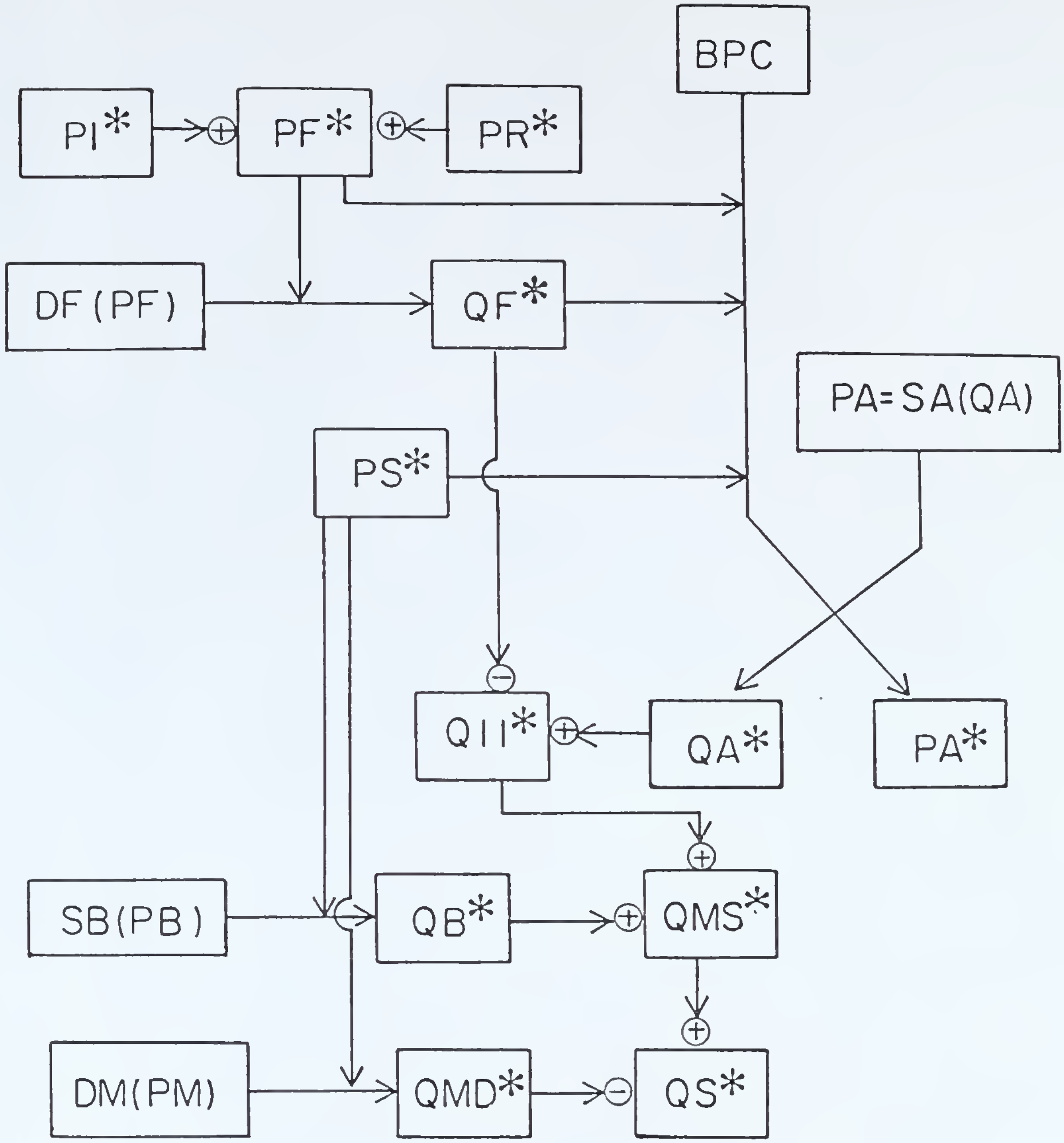


Figure 12. Equilibrium Solution for the U.S. Regulated Dairy Industry

(3.7) $QMSt \equiv QBt + QIIt$, the total quantity supplied of manufacturing milk is constituted by grade B and class II milk.

<u>Price conditions</u>.

(3.8) $PFt \equiv Pit + PRt$, the price processors pay for fluid milk is composed by the minimum market order price added by the cooperatives announced premium.

(3.9) $PAt \equiv PMt + (PFt - PMt)\ QFt/QAt$, formula for the blended price. The price received by farmers for the grade A produced, PAt, is a weighed average price. The weights being the quantities respectively allocated to the fluid and to the manufacturing market.

(3.10) $PMt \equiv PBt \equiv PSt$, identity between (a) priced paid by plants for manufactured milk products, PMt, (b) price received by farmers for grade B milk, PBt, and (c) price support by government, PSt.

Note that total demand for manufacturing milk is composed of quantities demanded by commercial outlets, QMDt, and government removals from the commercial market, QSt. This definition differs from the demand for manufacturing milk used in the studies reviewed in Chapter II. The other change in modelling the dairy market introduced in the above model is that a demand for class II milk is not included. As an excess of production over quantities consumed, class II milk is appropriately considered as part of the supply of milk available for manufacturing uses. Note that

the model refers to the national milk market and not to a specific region of the U.S.

After the mathematical exposition of the model, and after describing how equilibrium is obtained, two important steps must be taken. The first is to show that the model could be used to design alternative coordinating arrangements to reduce the imbalance between supply and demand of manufacturing milk. The second is to empirically estimate the model, test for its validation, and simulate the alternative coordinating arrangements. The next section takes care of the first step as described above.

Alternative Exchange Arrangements

This section will show how the model developed in the preceding section could be used to simulate alternative coordinating arrangements to bring the manufacturing milk market to a desirable institutional equilibrium. Before that, however, it is convenient to detail the jointly coordinating roles of two elements present in the model described above. They are the dairy cooperatives' pooling system and the price support program.

Coordination between Cooperatives and Dairy Farmers

Consider that the farmers expect to receive PA_c^* from their cooperative. Accordingly, they will be willing to produce $QA_c^* = n\ qA^*$, where n is the number of grade A milk farmers, and qA^* the quantity produced by an individual farmer which is determined from the first

order condition of

$$\text{(3.11)} \quad \text{Max } G \; PA_c^* \, qA - C(qA),$$

which is

$$\text{(3.12)} \quad PA_c^* = C'(qA), \text{ where } G \text{ is profit.}$$

However, PA_c^* is actually computed with values that the individual farmer does not control. PA_c^* is the result of

$$\text{(3.13)} \quad PA_c^* = (PF^* \, QF_c^* + PM^* \, QII_c^*)/QA_c^*,$$

where

QF_c^* is the quantity of grade A milk sold to processors,

PF^* is the unit price of QF,

QII_c^* is the quantity of grade A milk sold to manufacturers, and

PM^* is the unit price of QII.

These optimal values result from the cooperative marketing activities of assembling the grade A production from n farms and selling in the fluid and in the manufacturing milk market in such quantities that maximize.

$$\text{(3.14)} \quad PROF_c = PF \, QF_c + PM^* \, QII_c - C(QA_c),$$

subject to

$$\text{(3.15)} \quad QF_c \geq kQA_c, \; 0 < k < 1.$$

It is assumed that any administrative costs incurred by the cooperatives are independent of the quantities traded. No profits are retained and information from producers and buyers is available. The class I milk price PF is pre-announced, PF^*, and PM is supposed to be given as PM^*. The constraint reflects the marketing cooperative

perception that it could have enough power to allocate at least a fraction, k, of all grade A milk produced by its members in the class I milk market. Other implicit assumptions are that the marketing cooperative has control over QA_c, and that class I demand is prioritarily met. This problem corresponds to

$$(3.16) \quad \text{Max } L(QA_c, QF_c, \lambda) = PF^* \, QF_c + PM^*(QA_c - QF_c) - C(QA_c) + \lambda \, (kQA_c - QF_c).$$

The first order conditions are

$$(3.17) \quad \partial L/\partial QA_c = PM^* - C'(QA_c) + \lambda k = 0,$$

$$(3.18) \quad \partial L/\partial QF_c = PF^* - PM^* - \lambda = 0,$$

$$(3.19) \quad \partial L/\partial \lambda = kQA_c - QF_c = 0.$$

Substituting λ and k into 3.17, from their solution in 3.18 and 3.19, respectively results in

$$(3.20) \quad PM^* + (PF^* - PM^*) \, QF_c^*/QA_c^* = C'(QA_c^*),$$

which is the profit condition for the cooperative firm. Notice that the left hand side of equation 3.20 is equal to

$$(3.21) \quad PF^* \, QF_c^* + PM^* \, QII_c^*)/QA_c^*$$

which is exactly the right hand side of formula (3.13) used to calculate the blend price (PA_c^*) for grade A milk.

This result reveals that the assumptions imposed upon the behavior of the marketing cooperative are consistent with the current blend price formula used in the subsector for computing the grade A milk price. It is also the explicit condition for a coordinated equilibrium between grade A farmers and dairy cooperatives.

Now, take 3.21 (which is the blend price curve) and vary QA^*. The blend price curve, BPC, for given values of PF^*, QF^*, and PM^* is generated (See Figure 13). As it was shown above, the best of these optimum marketing values is determined only when cooperative members reveal their aggregate supply schedule, SA. (See Figure 14.) At the intersection of BPC with SA, the equilibrium between the marketing and the production segments is established.

Coordination between Cooperatives and First Users

Note that anytime PM^* changes, some adjustments are necessary in the BPC curve just derived. Suppose $PM' < PM^*$ is discovered to be the relevant price in the market this period. The BPC curve would then rotate downward around (PF^*, QF^*) as in Figure 15 below. BPC' would be the new blend price curve, derived with $PM = PM'$. The new marketing signal is supposed to be immediately perceived by farmers in the form of the new calculated blend price PA'. (See Figure 16.)

At this point, uncertainties that would exist with respect to the price of the manufacturing milk are drastically reduced when the price support level is pre-announced. The expected price for manufacturing milk in period t is equivalent to the prevailing support level previously established for that period. The instrument to transmit to grade A milk farmers the marketing alternatives at every price support level is the BPC curve. The BPC curve just derived will be used as an instrument to coordinate the exchange of crude milk between farmers and cooperatives and between farmers and the first users of crude milk. Basically, it

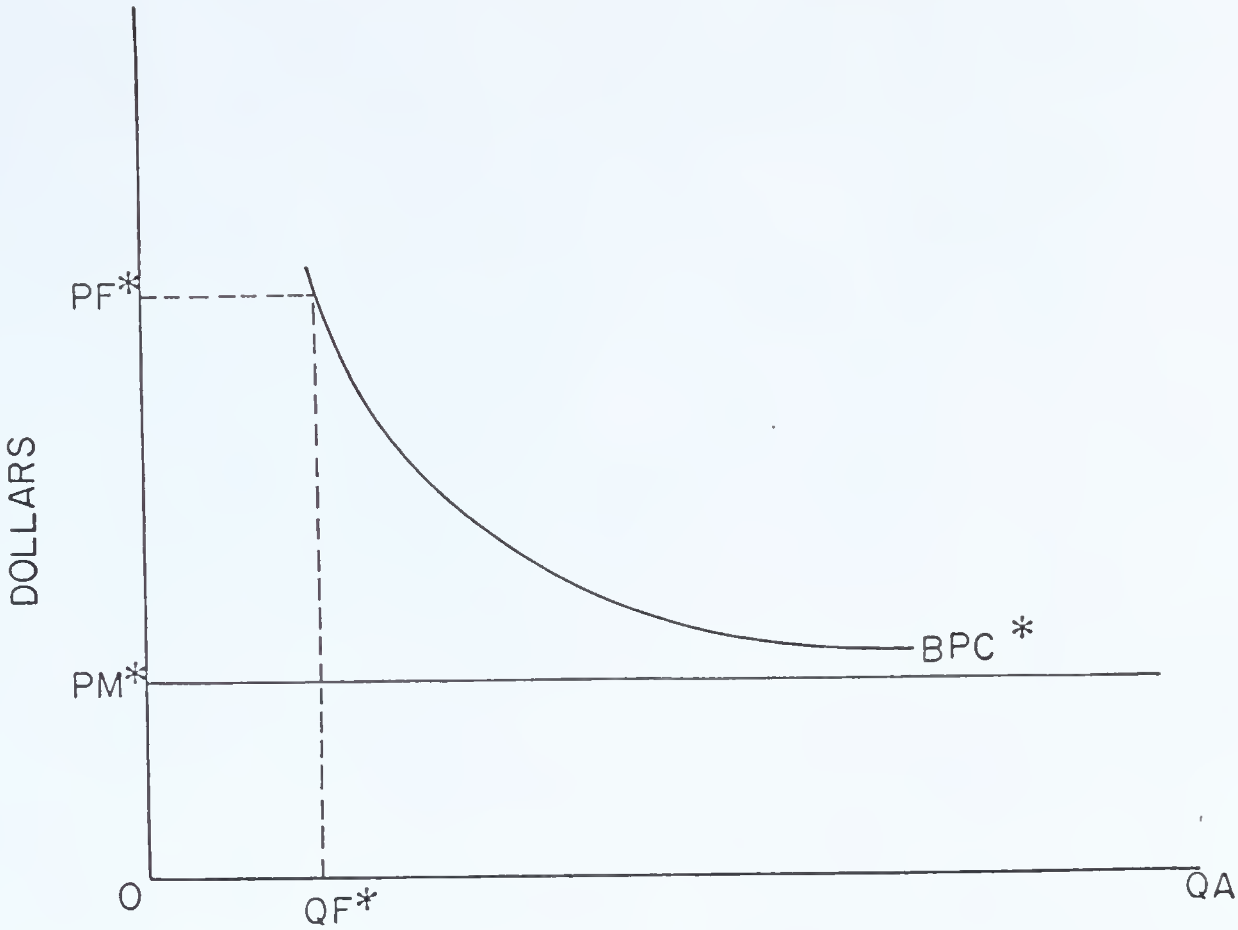


Figure 13. Blend Price Curve

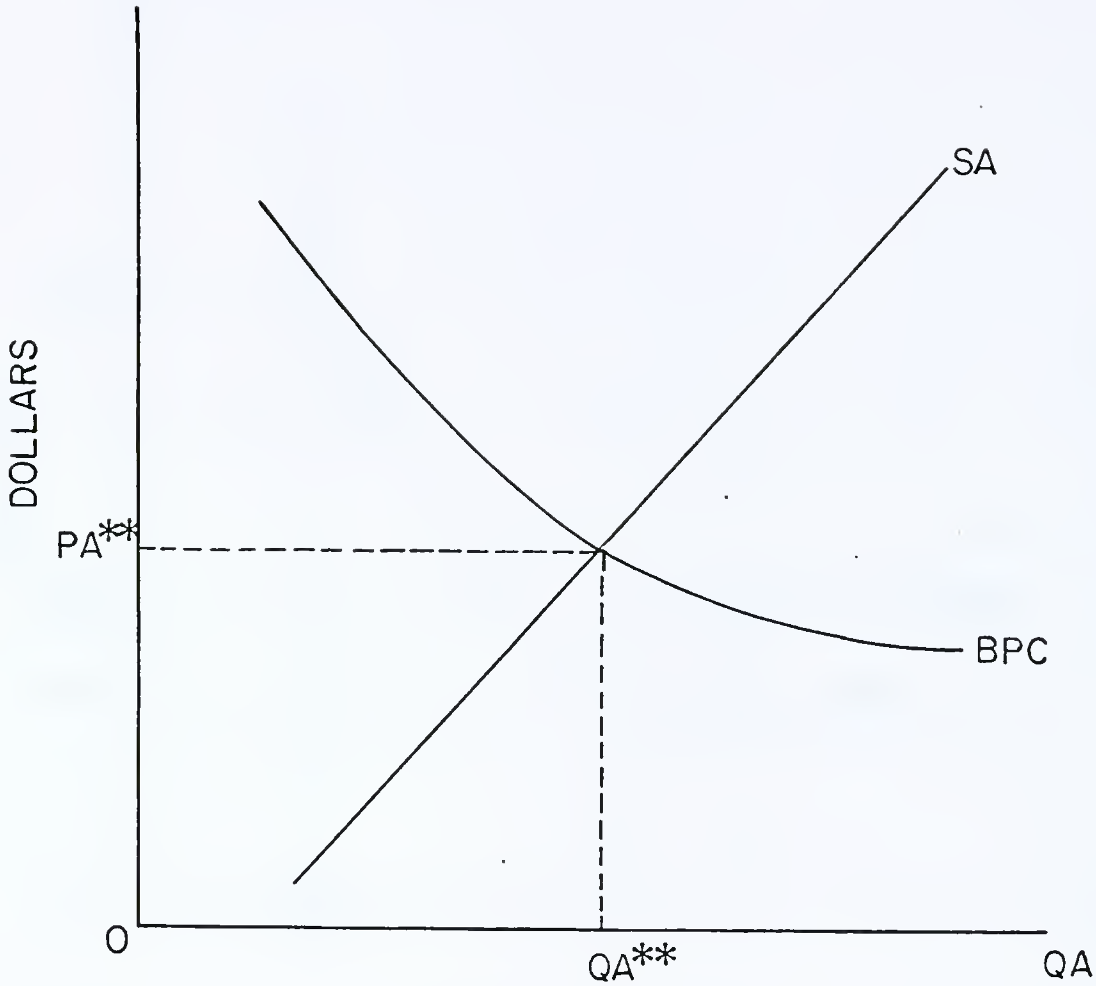


Figure 14. Equilibrium Solution in the Grade A Milk Market

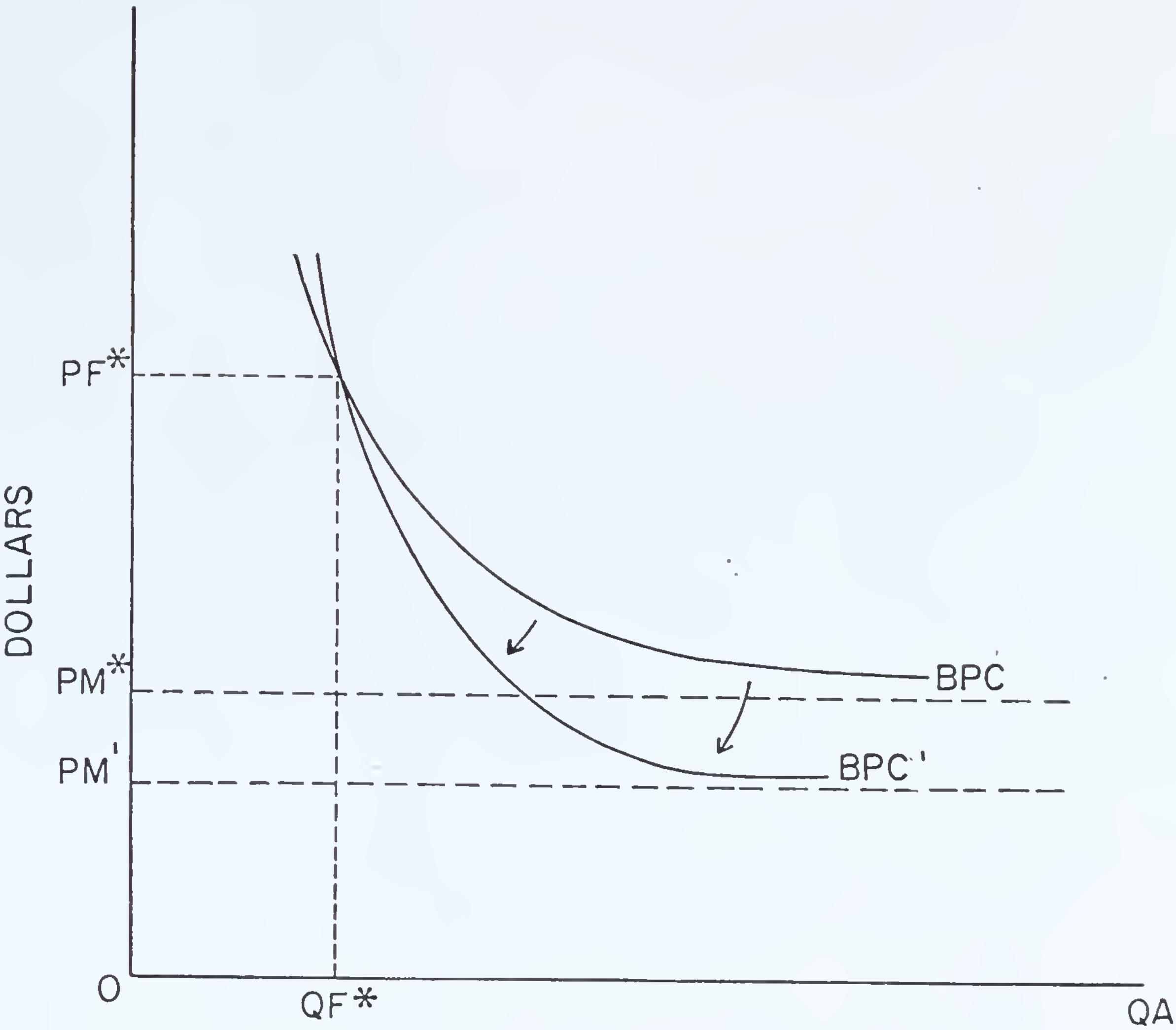


Figure 15. Rotation Movement of BPC Due to Changes in PM

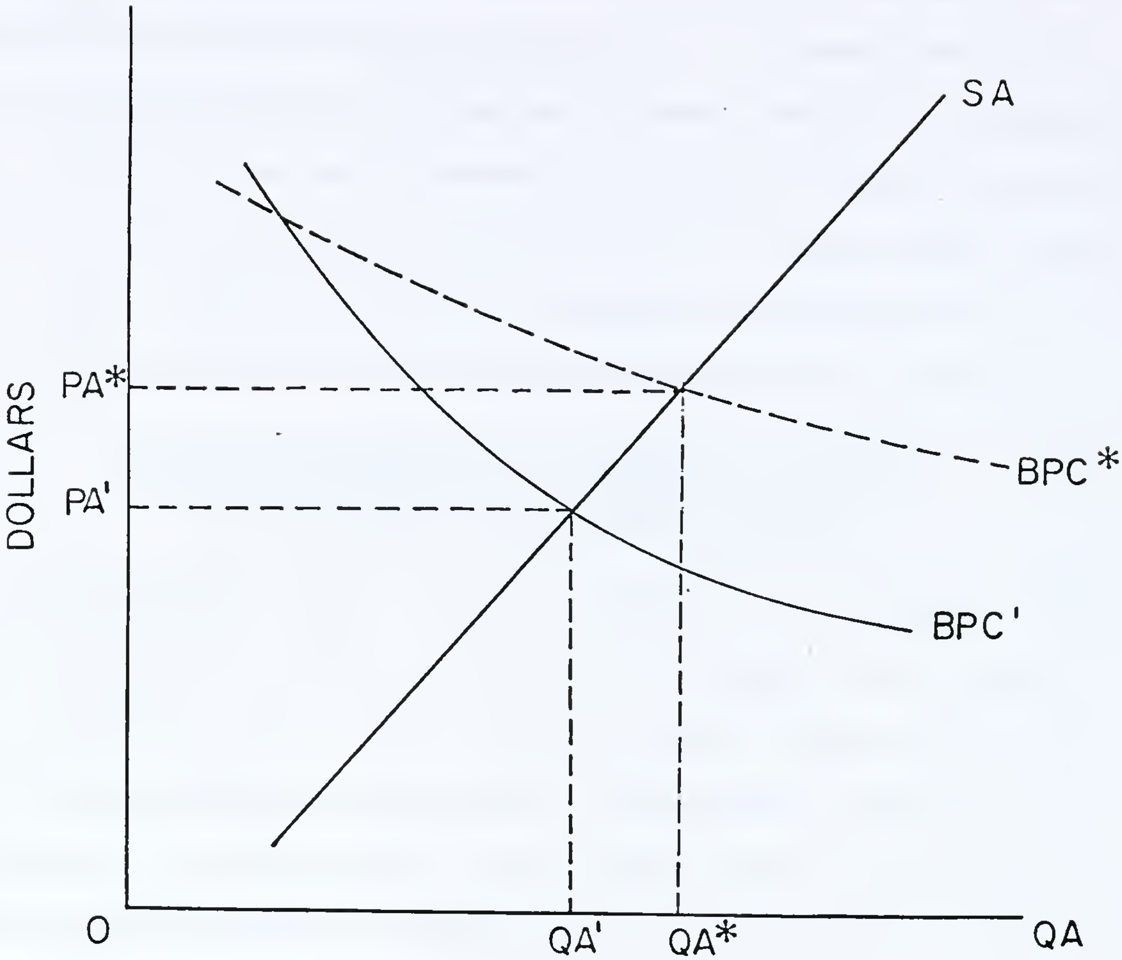


Figure 16. Effects of a Decrease in the Manufacturing Milk Price

plays the role of a "regulated total demand function for grade A milk." To cooperatives, BPC represents a set of marketing opportunities. To farmers, it reflects the prevailing demand conditions. Optimum prices and quantities can be derived. The BPC curve incorporates the possibilities of coordinating the responses of farmers because it is sensitive to the levels of a series of parameters including the level of the price supports. Since it establishes the coordinating linkage between partners that exchange crude milk in the dairy subsector, the BPC curve will be extensively used in the section that will deal with the simulations.

Alternative Coordinating Arrangements to Balance Supply and Demand of Manufacturing Milk

The Dairy Price Support Program has had four economic roles. The first three are interrelated and are primarily concerned with welfare of the dairy farm sector. The fourth role reflects concerns with controlling the physical production level. These economic roles are (a) in the short-run, to avoid income losses to dairy farmers in the spring season by holding possible breakdown in the milk prices, (b) in the long-run, to support dairy farmers income, and (c) stabilization of milk and dairy products prices. Recently, the price support program has assumed its new role as a coordinating mechanism to reduce surplus of milk. The provisions of the program were changed to conform it to this new function. The price support level is not as closely tied to its "parity" concept.

The model developed in this chapter will be used to examine how the price support program, as a coordinating instrument, can accomplish the objective of reducing the unbalance between supply and demand for manufacturing milk. All the alternatives of balancing supply and demand for manufacturing milk contemplate the production side of the milk market only. Advertising and promotions, as well as other disposal features, are excluded from the analysis.

As farmers and cooperatives become the focus of attention of the coordinating measures, preferences will be measured in terms of the total net revenue that would be foregone by milk producers under each set of alternatives. All the simulations start with, and are compared to, the dairy subsector in estimated "regulated equilibrium" as depicted in Figure 11.

Self-Regulation

Suppose government announces that it would not buy quantities of dairy products in excess of $\overline{QS}$ equivalent milk, at the prevailing price $\overline{PS}$ (Figure 17). The dairy farmers, organized in cooperatives, have at least two options to accomplish this demand restriction. One is to impose a production quota on themselves (a nonprice type mechanism of coordination). The other is to block distribution of part of the proceedings from pooling (price mechanism). These two alternatives will be discussed next.

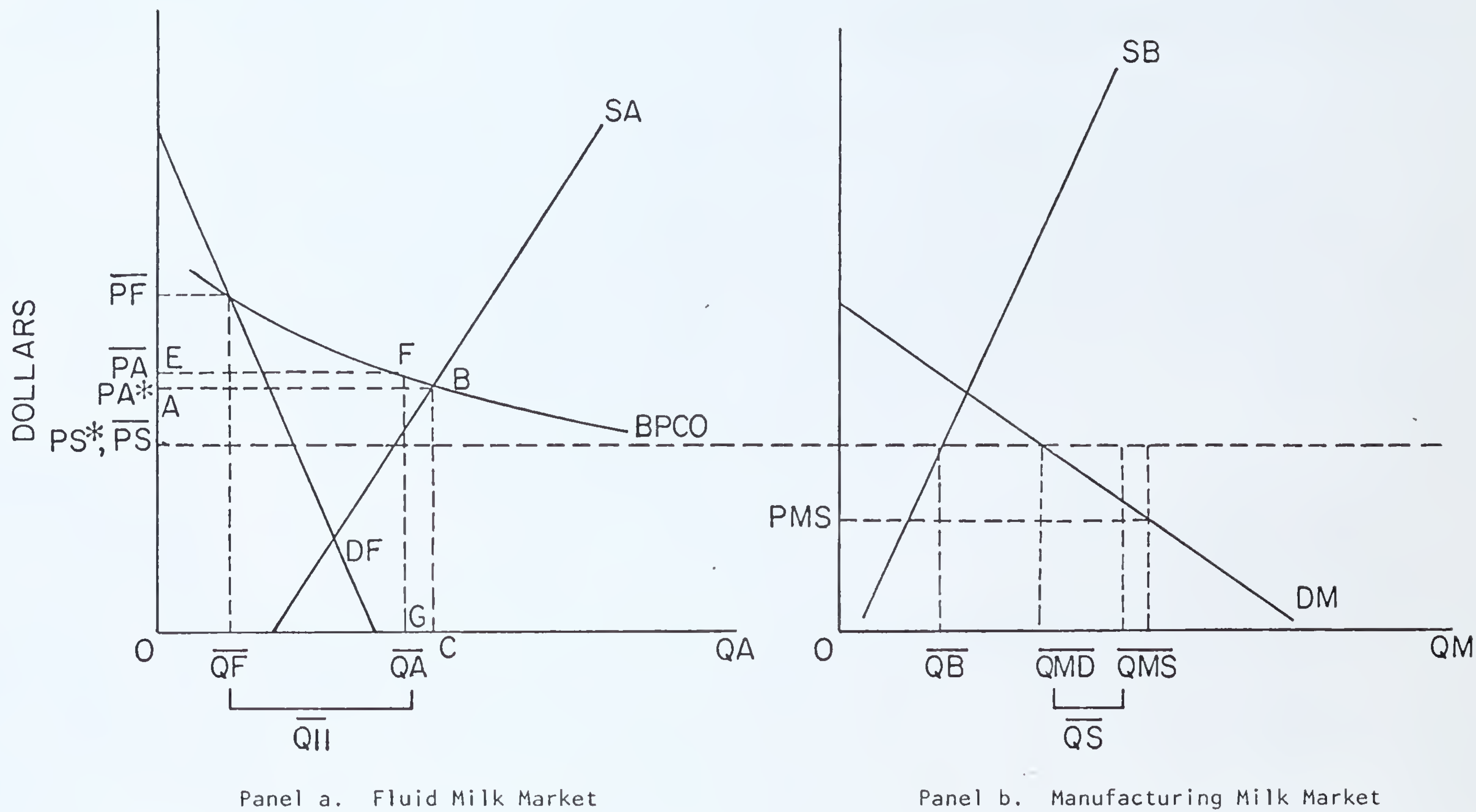
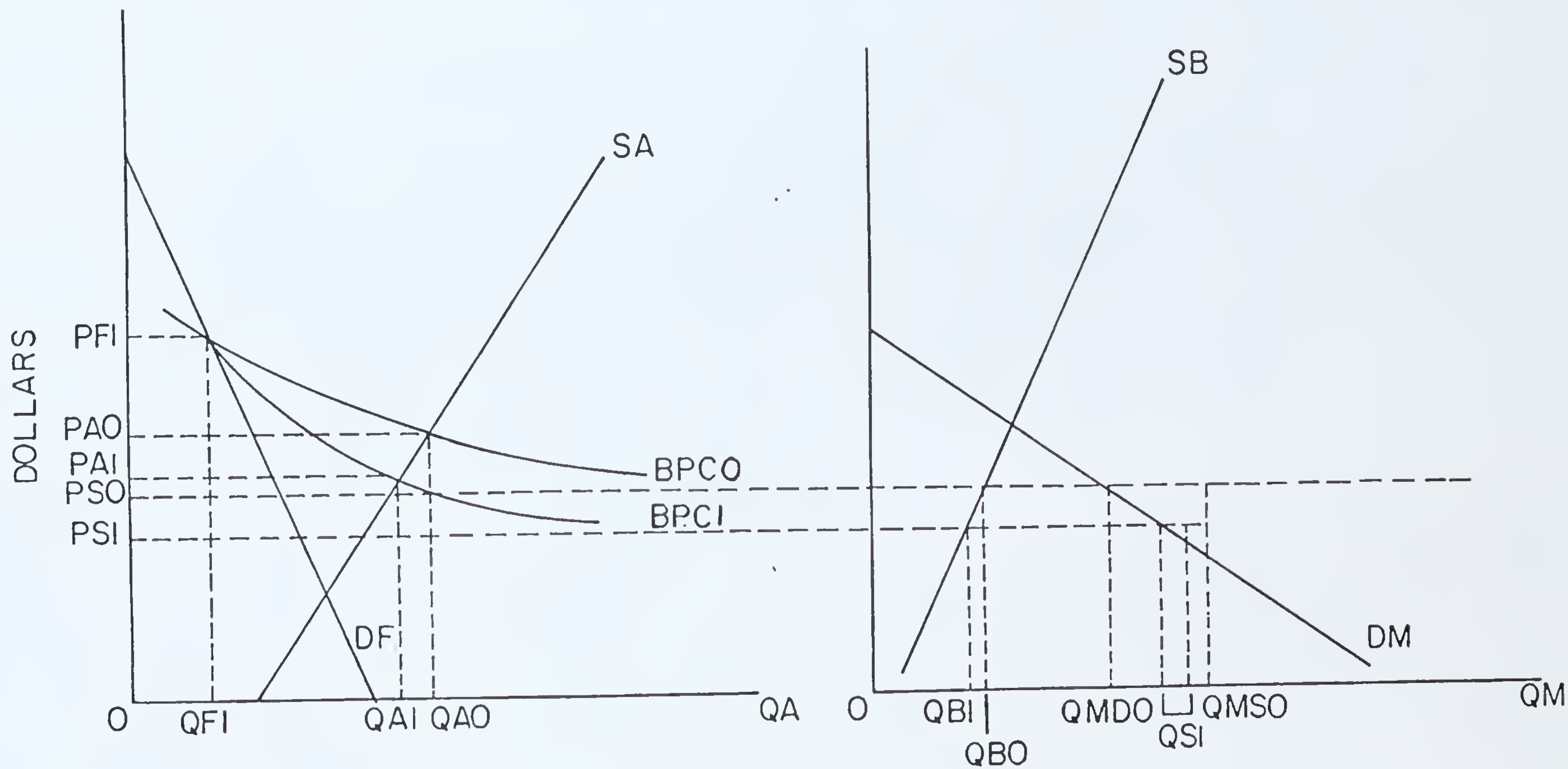


Figure 17. Reducing Milk Surplus by Restricting Grade A Milk Production

Restricting the quantities produced of grade A milk. Suppose that dairy cooperatives are pressed by the government to reduce the manufacturing milk surplus. The choice could be to impose a quota on each member's production. The grade A milk farmers, organized in cooperatives, must examine the alternatives in order to accomplish the government demand restrictions. The alternative which generates the least loss in revenue should be preferred by producers. One of the ways to satisfy both the demand schedule for fluid milk, and the commercial derived demand for manufacturing milk, and make only $\overline{QS}$ available to the government (Figure 17) is a self imposed limit on the farmer's production of fluid eligible milk. The equilibrium values for the milk market with the classified pricing, pooling, and price supports are given by the vector ($\overline{PA}$, $\overline{QA}$, $\overline{QII}$, $\overline{PF}$, $\overline{QF}$, $\overline{PS}$, $\overline{QB}$, $\overline{QMS}$, $\overline{QS}$, $\overline{QMD}$).

After allocating $\overline{QF}$ to the fluid milk, $\overline{QII}$ is sold to the manufacturing milk market. When $\overline{QII}$ is added to $\overline{QB}$, which has been produced at the price support $\overline{PS}$, $\overline{QMS}$ is generated. $\overline{QMS}$ is the supply of available manufacturing milk after the quota. The blend price the cooperatives will be able to pay their member producers is $\overline{PA}$, which is above the equilibrium price PA^*. The change in revenue for the grade A dairy farmers can be measured by the difference between the rectangles ABC and EFG.

Cooperatives blend price control. The cooperative board [USDA, 1981, p. 26] may choose to pay a blend price that would induce producers to generate exactly the amount limited by the government QSI, at PSO (Figure 18).



Panel a. Fluid Milk Market

Panel b. Manufacturing Milk Market

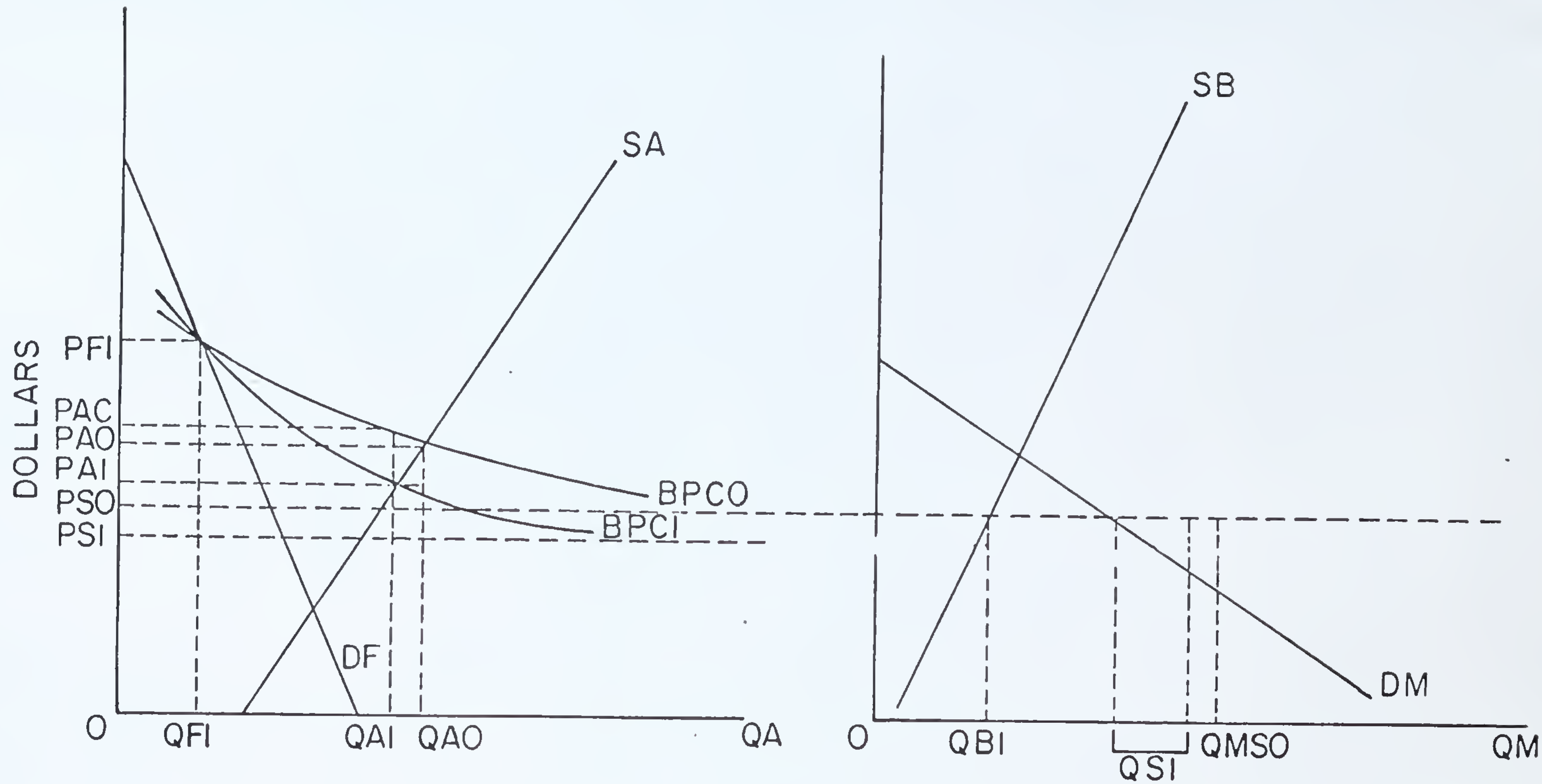
Figure 18. Reducing Milk Surplus by Restricting Distribution of Proceedings from Grade A Milk Marketing Sales

Suppose that cooperatives, being aware of all the schedules in the milk market, project that the government restriction QS1 (Figure 18), could be met if the proceedings from the marketing of the crude milk were computed at the price PS1 instead of PS0. According to the BPC schedule, PA1 would be paid to producers for each unit of grade A produced, QA1. Revenue losses to producers will be in the order of (QA1 PA1 - QA0 PA0). Part of this loss in revenue, $(PA_c - PA1)QA1$ would be retained by cooperatives.

Alternative Government Controls

The next four alternatives assume increasing government's role with additional coordinating measures. They are: (a) product differentiation support prices; (b) deficiency payments; (c) taxing output; and (d) selective price supports.

Product differentiation support prices. Suppose the government finds enough reasons to assert that surpluses are due to excess supply of grade A milk and thus decides to impose a lower price support to products manufactured with grade A milk. With the same objective of former alternatives, the price support to be imposed on grade A farmers will be PS1, as in Figure 19. In this case, besides the decrease in gross revenue of about (PA0 QA0 - PA1 QA1), the cooperatives would not be able to retain $(PA_c - PA1)QA1$. Of course the operationalization of this alternative would require adjustments in the current administrative mechanisms to allow government to control the price support levels according to the product origin (grade B or fluid eligible milk).



Panel a. Fluid Milk Market

Panel b. Manufacturing Milk Market

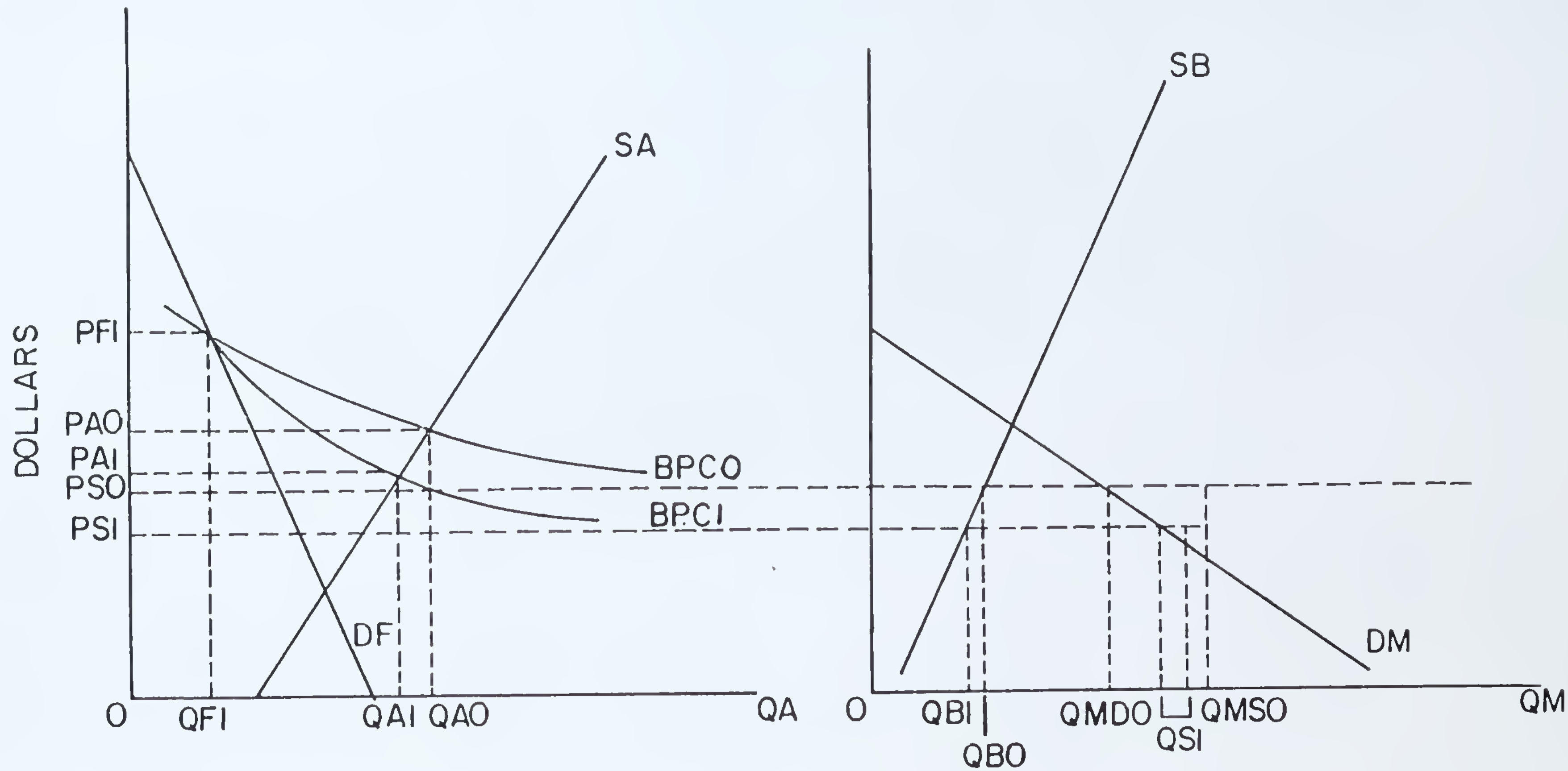
Figure 19. Reducing Milk Surplus by Differentiating Support Prices

Deficiency payments. If government decides that all milk produced should be sold to commercial markets, the price of manufacturing milk would drop to PMS (Figure 17). Government expenses with this alternative would have been $(\overline{PS} - PMS\ \overline{QMS})$.

Taxing output. Instead of either self-regulation or differentiating support prices according to milk classification, the alternative may reside in taxing. The government with the objective of reducing its total purchases decides to collect a once-for-all dollar tax on every hundred pounds of marketed milk, if quantities exceed QA1 (Figure 18). The exact amount of taxes per cwt. is given by (PA0 - PA1) in Figure 18. Of course producers may decide to market QA0 and be assessed by (PA0 - PA1) QA0, or to reduce production to QA1 and lose (PA0 QA0) - (PA1 QA1) in revenues.

Selective price support levels. Suppose the government decides to use its discretionary power over the price supports level to signal to farmers its intention in seeing the formation of the milk surplus reduced. The short- and long-run effects on the dairy farm sector will be examined next.

The long-run effects (Figure 20) shows that a permanent reduction in the level of the price support from PS0 to PS1 will reduce government purchases of manufacturing milk to QS1 = (QMS1 - QMD1). Total production of grade A milk will be reduced to QA1, and farmers will receive PA1 for each unit produced. The reduction on the government purchases is drastic. Grade B production decreases along with a reduction in



Panel a. Fluid Milk Market

Panel b. Manufacturing Milk Market

Figure 20. Reducing Milk Surplus by Selecting Support Price Levels

class 2 and 3 quantities. The commercial demanders now take more at the lower price.

The short-run analysis is important because it introduces aspects that are similar to policies recently proposed. The concepts of short- and long-run supply functions, as defended by Becker [1971, pp. 79-83] are needed here. Figure 21 depicts the short- and long-run supply curves SS and SL, respectively, for grade A milk. Assume that the equilibrium prices and quantities, P0 and Q0, have been observed for an indefinitely long period. A price decrease to P1 would have a different impact on the quantities of milk produced depending on the way farmers interpret that movement of prices. In the analysis of the preceding alternative it was assumed that farmers understood that the price support decrease was a permanent move taken by CCC.

However, News for Dairy Co-ops [NMPF, 1982] indicates that the price freeze at $13.10 (current dollars) would be suspended by 1984, when it would be again corrected to follow its parity concept. To the extent that farmers become aware of this "news," it is very likely that the response to the price (real) decrease would be made along their short-run supply curve. The return to the "parity" concept after a short period of time may indicate to farmers that the price decrease will be a temporary measure. Adjustments would then be made mostly through decreasing the use of variable factors. Farmers would not dispose of their fixed factors, but would reduce their utilization, waiting until prices returned to original levels.

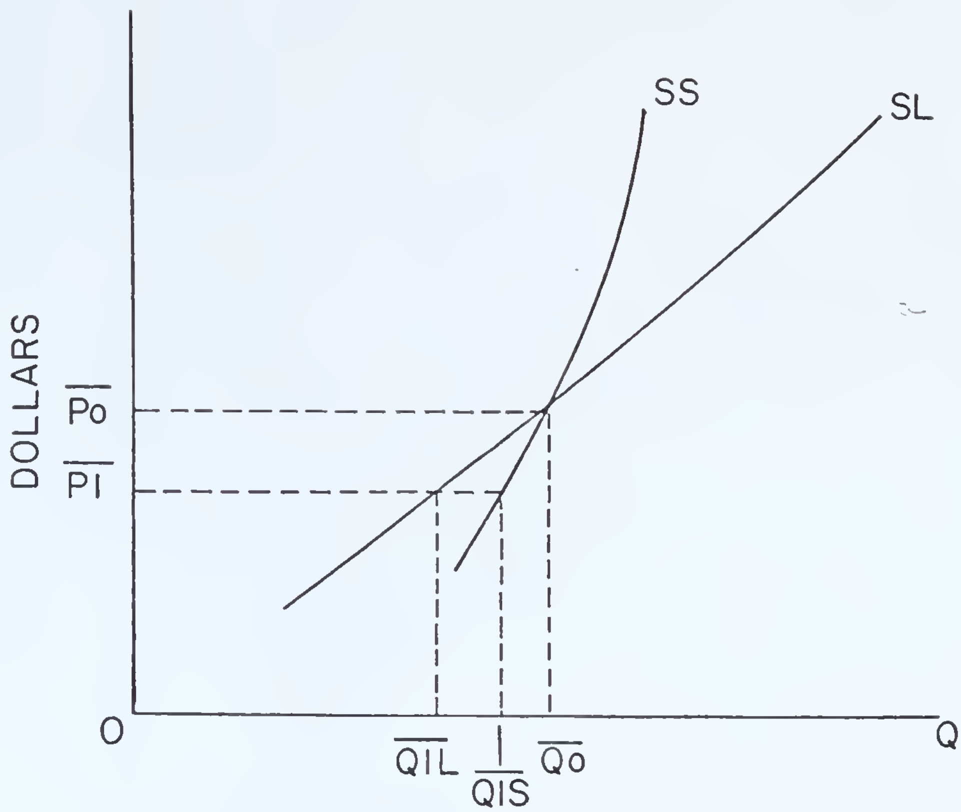


Figure 21. Impact of Temporary or Permanent Decrease in Price on the Quantities Produced

Currently, the House of Representatives has established that the temporary freeze of the manufacturing milk price supports would end by 1984, but that the real price would not go back to its original level (1982). It would rather be kept at its real value of October 1, 1983, estimated at 63 percent of parity. Note that no reasons are given for this decision. It seems that by coming back to the parity level, "a concept that the Federation (NMPF) considers an absolute necessity in the support program," will again link the program objective to its income support issue. Becker's analysis of short-run equilibrium is suitable for this situation and may be used to simulate the effects of the current freeze under some special circumstances. Bringing his analytical framework into the model for the dairy industry, the short-run equilibrium values after a temporary decrease in the price support level can be obtained.

Note that as a result of the above analysis the availability of manufacturing milk for government uses will be larger than if the farmers had believed that price would have been permanently frozen at some given level.

Summary

After having introduced the problem of this study in Chapter I, and having reviewed the relevant literature in Chapter II, the model and what can be conceptually done with it to assess the problem was just addressed in this chapter. The empirical estimations will be discussed

in Chapter IV. In Chapter V the estimated relationships will be used to validate the conceptual model and to execute the simulations discussed in this chapter.

CHAPTER IV
FORMULATION OF THE EMPIRICAL MODEL

Introduction

In the last chapter, derived demand curves for fluid and manufacturing milk, supply curves for grade A and grade B milk for the United States were identified as the basic components of the conceptual model. Their empirical estimation will be essential since the available estimates were considered inadequate for the purpose of this study. A decision was made that the national functions would be obtained by using "pooling" cross-sections over time series techniques. This procedure makes the maximum use of available information and enriches the sample basis [Judge, 1982, p. 475]. The Federal Milk Marketing Order market is chosen as the cross-sectional unit on the demand side and the state is judged to be a natural choice for the cross-sectional unit for the estimation of the supply functions. The availability of information oriented toward these selections. The explanatory variables to be included in the empirical estimation of the above functions can be identified from a theoretical derivation, which will be included in Appendix A. This chapter reports the selected specifications, the variables that will be used in their empirical estimation, as well as the data sources. Results are presented after a brief discussion of the respective estimators.

Variable Identification

The explanatory variables are, in general, identified from theoretical derivations performed in Appendix A. Explanatory variables not explicitly identified in the derivations are adequately discussed in the next sections.

Demand Functions

The concept of a derived demand function is used in this study for two basic reasons. First, the market stage under investigation is an intermediate market. Second, it would be very difficult to estimate the final demand for crude milk. Besides, given the objectives of this study, there are no major theoretical or practical reasons for not using this approach.

Market order derived demand function for fluid milk. The processor buys grade A milk and other inputs to produce fluid milk products, a class I use. A unique relationship between purchases of raw milk and its price is found (See Appendix A) to be like equation (4.1) if profit maximization is assumed and if perfect competition is the environment in which trade takes place.

(4.1) $qf = df(pf, po, w, e)$,

where

qf is the quantity of raw grade A milk purchased by the processor,

pf is the unit price of qf,

po is price received by processor for output sales,

w and e are prices paid by processors for nomilk inputs--wage and energy, respectively.

A market order derived demand function is assumed to be a horizontal summation of individual processor derived demand functions, and all the derived demand functions, for all market orders, can be written as

(4.2) $QF = DF(PFR_r; PO; W; E; Y; S_1,\ldots,S_r)$.

Given the regulated milk market and the assumptions of perfect competition, all the explanatory variables in the demand equation for fluid milk are considered exogeneous variables. PO, W, and E are assumed to be given since perfect competitive output and input markets are assumed for all nonmilk inputs.

In general, when price and quantities in a market are jointly determined, both price and quantity variables are considered endogeneous to the model. Administrative price discovery techniques change the econometric nature of price as an explanatory variable. The price of fluid milk, PF, becomes exogenous in the equation (4.2). The Federal Milk Order Marketing system establishes a minimum unit price that the processor must pay for QF, PI^*. Very often, PR^*, a pre-announced premium over class I prices, are added to PI^*.

The variable Y is introduced to capture the effects of the market size on the total quantities demanded in each cross-sectional unit. Y is total personal income by Federal Milk Order markets. The advantage in using Y instead of dummy variables is that it saves degrees of freedom in two ways. First, by reducing the number of variables that otherwise would be included to isolate the effects of the market size.

Second, because it jointly captures the effects of population (the market size) and per-capita personal income (the specifics of each market). Furthermore it has the advantage over "zero-one" variables because λ could also shift the intercept across time.

The variables PFR_r are the price of fluid milk in all marketing orders included in region r, r = (1,...,9). R_r are defined as variables that assume the value one when the cross section unit is included in region r, and zero otherwise. The regions considered are the nine census regions (modified) defined for the United States (Figure 22). The hypothesis is that the response of the dependent variable to PF is different for different regions, but it is constant over the period of analysis.

Finally, S_s, s = (1,...,4) are dummy variables to account for seasonality in the derived demand for fluid milk by processors.

Market order derived demand function for manufacturing milk. The manufacturer buys milk, either grade B or grade A, to produce nonfluid dairy products such as ice cream, sour cream, cottage cheese, cheese, butter, nonfat dry milk, and condensed milk. Assuming profit maximization as an objective, and perfect competition in both input and output markets, a demand function for crude manufacturing milk is derived (See Appendix A). The demand for all manufacturers in the U.S. is assumed to be just a horizontal summation of the individual manufacturer demand functions. Some adjustments are introduced to fit the equation into the selected estimation technique. Its final specification is

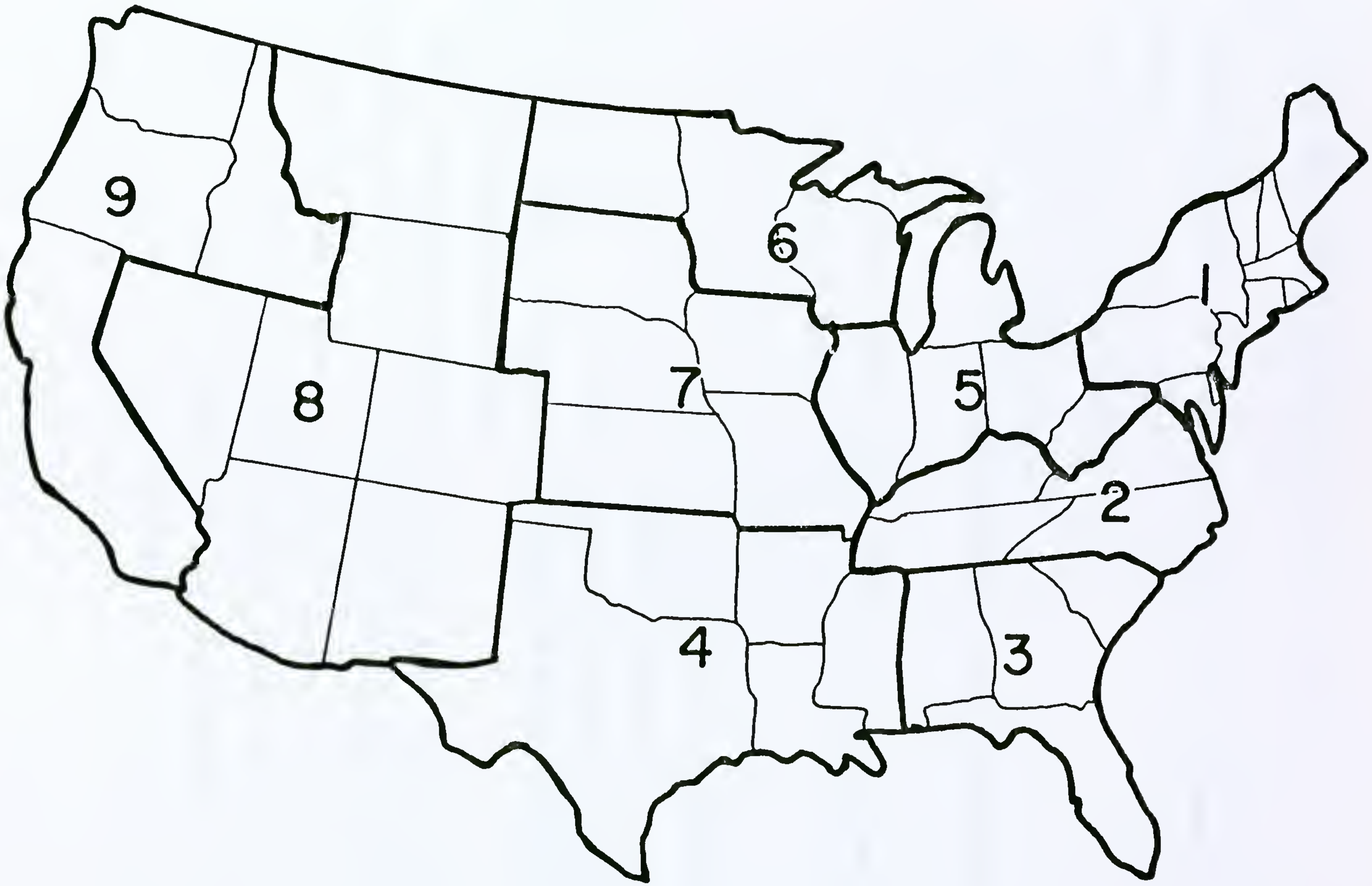


Figure 22. Regions of the United States

(4.3) $QMD = DM(PMR_r; POM; WM; EM; Y; S_1,...,S_4)$,

where

QMD is the quantity of commercial manufacturing milk purchased by plants,

PM is the unit price of QMD,

R_r are regional dummies, $r = (1,2,4,...,9)$,

POM is an index of prices received from the sales of manufactured dairy products,

WM, EM are prices of nonmilk inputs, labor and energy, respectively,

Y is total personal income by marketing order,

S_s are quarterly seasonal variables, $s = (1,...,4)$.

For the same reasons as the ones related in the derived demand for fluid milk, all the right-hand-side variables of equation (4.3) are exogenous variables. Y is included to capture the effects of the manufacturing milk market size (population), and its specifics (per-capita income), on the quantities demanded.

PMR_r is an interaction between PM, the unit price of QMD in each cross-sectional unit, and R_r, a dummy variable which assumes the value one if the Federal Order market is included in region $r = (1,2,4,...,9)$. Such regions are based on the modified nine U.S. census regions (Figure 22). The region composed by Alabama, South Carolina, Georgia and Florida is left out. It accounts for only one percent of the manufacturing milk marketed in the U.S.

Supply Functions

In Appendix A it was assumed that a typical dairy farmer produces either grade A, grade B, or both types of milk. In that Appendix, the reasons behind this assumption and the corresponding derivations of the respective supply functions can be found.

Supply function for fluid eligible milk. The supply function for all producers of grade A milk in any cross-sectional unit would be the horizontal summation of the supply function derived for the individual farmer. The general form a supply function representing all cross-sectional units can be written as

$$(4.4)\quad QA = SA(PA_t R_r;\ PA_{t-1},\ldots,PA_{t-4};\ PA_{t-13},\ldots,PA_{t-16};$$
$$PB_{t-1};\ C;\ PDF;\ PMC;\ S_1,\ldots,S_4).$$

where

QA is the quantity of grade A milk produced and sold to plants by dairy farmers, by state,

PA is the unit price of QA,

R_r is a dummy variable which assumes the value one if the cross-section is included in region r, r = (1,...,9). Such regions are based on the nine U.S. census regions (modified) as shown in Figure 22.

PB is the price received by dairy farmers for grade B milk sold to plants,

C is the number of milk cows in the state,

PDF is the price of dairy feed with sixteen percent proteins,

PMC is the price of milk cows, and

$S_1, \ldots, S_4$ are quarterly seasonal variables.

The price of grade B milk, lagged one period, is introduced to capture the conversion of grade B milk to grade A milk. Milk cows are an asset to the dairy farmers. As the value of cows (PMC) increases, farmers expand their herd size which increases milk production [Novakovic and Thompson, 1977, p. 514]. The number of milk cows in the state, C, captures the effect of the cross-sectional unit size on the quantities supplied.

As it was also observed in Chapter II, milk supply functions should include lagged explanatory variables. Recently Levins [1982], and Chavas and Johnson [1982] have suggested that the lagged structure should follow the biological characteristics of the industry to which supply estimations are referred to. Accordingly, the responses of dairy farmers to price variations would be more intensive in the beginning and end of a period defined between the instant the milk price is changed and the production of milk by calves raised because of that price increased motivation.

Milk produced by U.S. farmers shows a very definite seasonal pattern. Spring and summer volumes are always greater than the output obtained in the fall and winter. Some exceptions are observed for some of the southern states. Seasonality in milk production has been observed extensively in the dairy literature. Rojko, for example, noted that "consumption of milk was at a minimum during June, July, and August, when supplies were in a relatively surplus position, whereas production of milk tends to be the least in November and December, when sales in

most markets are above their annual average." [1957, p. 12]. Recently, in a study about seasonal deliveries by cooperatives, Ling observed that "milk production peaks in spring and bottoms out in fall. Fluid demand is higher in early spring and fall than in summer and winter." [1982, p. iii].

The econometric implications of such patterns are that other reasons than economic ones are influencing variations in production. Such exogenous and perhaps uncontrollable factors should be adequately treated. Elimination of the variations would improve the efficiency of the estimator, since reductions of variances of the estimated parameters would certainly be observed. One usual procedure to take care of seasonality is the dummy variables technique. In the present supply model

S_s = 1, if data refers to the sth quarter,

S_s = 0, otherwise; s = (1,2,3,4).

Supply function for grade B milk. The dairy farmer supply function for grade B milk is derived in Appendix A. A quantity dependent relationship for all cross-sectional units can be written as

(4.5) $QB = SB(PB;\ PA_{t-1},\ PA_{t-2};\ PDF,\ FW;\ PC;\ E;\ S_s;\ ZSB_u)$.

where

QB is the quantity of grade B milk produced and sold to plants, by state,

PB is the unit price of QB,

PA is the unit price of grade A milk,

PDF is the price of sixteen percent dairy feed,

FW is farm wage rate,

PC is the price of beef cows,

S_s are quarterly seasonal variables,

ZSB_u is the intercept shifters for each cross-sectional unit.

Lagged fluid eligible milk prices were introduced in the above specifications to isolate the effects on the supply response of grade B milk caused by conversions to the grade A milk activities. Such conversions are not instantaneous because it requires additional investment and the approval of the sanitary authority.

Note that all right-hand-side variables of equation 4.5 are exogenous except the price of grade B milk. The government guarantees the price of cheese, butter and nonfat dry milk, not the price of the crude milk input. Fixing a floor the manufacturer's output prices only limit the input price variations. At the farmer-manufacturer interface, the variation in price is still a function of the quantity produced of grade B milk. Therefore, the demand function for crude grade B milk is specified as

(4.6) $PB = DB(QB;\ Y;\ S_1,\ldots,S_4;\ ZDB_1,\ldots,ZDB_{25})$

where

PB is the price paid by plants for grade B milk,

QB is the quantity of grade B milk sold to plants,

Y is total personal income,

$S_1,\ldots,S_4$ are quarterly seasonal variables, and

$ZDB_1,\ldots,ZDB_{25}$ are intercept shifters for each cross-sectional unit.

The joint dependence configuration between PB and QB in the above relationships requires that a simultaneous system approach be used in their estimation [Kennedy, 1979, p. 37].

Data

Data for empirical estimation of the supply and demand functions described in the last section are needed. The major sources are the Dairy Division, Agricultural Marketing Service, USDA; Crop Reporting Board, and Economic Division, Statistical Reporting Service, USDA; the Commodity Credit Corporation, ASCS, USDA; the Bureau of Labor Statistics, USDL; and the Bureau of Economic Analysis, USDC. Books, other general publications, special tabulations, tapes, and computer printouts were the most frequent forms in which the data were obtained. Telephone calls and letters were the means of communication used in the contacts with respective officials from those government agencies.

Table 4 contains a summary of all the variables used in the model estimation. Most of them are constructed variables because of needed adjustments in either the period or the geographical unit in which the primary statistics were obtained. Each state's manufacturing grade milk (grade B) is divided among the Federal Marketing Orders in the same proportion as each state's grade A milk production. Also, when the explanatory variables for the Federal Order demand equation are available only at the state level, an average value was constructed by weighing the values of each state by the proportion of the Federal Order's population coming from each state.

Table 4. Variable Name, Definition and Unit

Variable Name	Definition	Unit
Derived Demand for Fluid Milk		
QF	Quantity of raw grade A milk purchased by processors, by Federal Order Market, by quarter	1,000 lbs.
PF	Price paid by processors for fluid eligible milk, by Federal Order Market, by quarter	$ per cwt.
R_r	A dummy variable indicating whether a given Federal Order is included in region r = (1,...,9)	zero-one
PO	Index of prices received by processors for fluid milk products, by Federal Order Market, by quarter	1967 = 100
W	Wage rate in the milk processing plant, by Federal Order Market, by quarter	$ per hour
E	Energy, price paid by the milk processing plant, by Federal Order Market, by quarter	$ per 100 kw.
Y	Total personal income by Federal Order Market, by quarter	mil. $
S	Quarterly seasonal variable	zero-one
Derived Demand for Manufacturing Milk		
QMD	Quantity of commercial manufacturing milk purchased by plants, by Federal Order Market, by quarter	1,000 lbs.
PM	Price paid by plants for manufacturing milk, by Federal Order Market, by quarter	$ per cwt.

Table 4. Continued

Variable Name	Definition	Unit
R_r	A dummy variable indicating whether a given Federal Order is included in region r = (1,2,4,...,9)	zero-one
POM	Index of price received by manufacturers for dairy goods produced, by Federal Order Market, by quarter	1967 = 100
WM	Wage rate in the manufacturing milk plant, by Federal Order Market by quarter	$ per hour
EM	Energy, price paid by the manufacturing milk plant, by Federal Order Market, by quarter	$ per 100 kw.
Y	Total personal income by Federal Order Market, by quarter	mil. $
Supply for Grade A Milk		
QA	Quantity of fluid eligible milk produced and sold to plants, by state, by quarter	mil. lbs.
PA	Price received by farmers for fluid eligible milk sold to plants, by state, by quarter	$ per cwt.
R_r	A dummy variable indicating whether a given state is included in region r = (1,...,9)	zero-one
PB	Price received by farmers for grade B milk sold to plants, by state, by quarter	$ per cwt.
C	Number of milk cows, by state, by quarter	1,000 head
PDF	Price paid by farmers for sixteen percent protein dairy feed, by state, by quarter	$ per ton

Table 4. Continued

Variable Name	Definition	Unit
S	Quarterly seasonal variable	zero-one
PMC	Price received by farmers for milk cows, by state, by quarter	$ per head
Supply for Grade B Milk		
QB	Quantity of grade B milk produced and sold to plants, by state, by quarter	mil. lbs.
PB	Price received by farmers for grade B milk sold to plants, by state, by quarter	$ per cwt.
PA	Price received by farmers for fluid eligible milk sold to plants, by state, by quarter	$ per cwt.
PDF	Price paid by farmers for sixteen percent protein dairy feed, by state, by quarter	$ per ton
FW	Farm wage rate, by state, by quarter	$ per hour
PC	Price received by farmers for beef cows, by state, by quarter	$ per cwt.
E	Energy, price paid by dairy farmer, by state, by quarter	$ per 100 kw.
S	Quarterly seasonal variable	zero-one
ZSB	Intercept shifters, by state	zero-one
Other		
SDEF	Supply Deflator: Index of price received by farmers, by state, by quarter	1967 = 100
DDEF	Demand Deflator: Index of price received by processors and manufacturers, by Federal Orders, by quarter	1967 = 100

Finally, all data should preferably refer to a quarterly basis. Some aggregation of monthly, as well as disaggregation of yearly, issued information will be necessary Also, note that it is implicitly assumed that all regulated grade A milk delivered to a handler regulated under Federal Order j, is sold to a processor or to a manufacturer in that Federal Marketing Order.

Table 5 contains all the variables used in the estimations, the variables used in their construction, and respective sources.

Period of Analysis

The upper limit of the time series was set at the fourth quarter of 1981, which was the most recent period that a complete set of information was available. Beginning in 1982, some important modifications were introduced into the legislation of the price support program, altering the observed homogeneity. This is the very reason why the lower limit of the time series was set at 1977. Homogeneity was basically looked upon with respect to the industry structure. Two variables that may alter the industry structure are changes in the Federal Order milk marketing structure and the frequency per unit of time that price supports are announced. A period in which both variables were kept constant would be better isolated from external and undesirable shocks. Besides, the choice of a homogeneous period would minimize aggregation problems if aggregation were required, or at least would improve comparability of data.

Table 5. Data Used to Construct Variables, Definition and Source

Variable Name	Data Name	Definition	Source
QF	QCIjM	Producer milk used in class I by handlers regulated under Federal milk order by Federal market, by months, 1,000 lbs.	Agricultural Marketing Service, USDA, (Computer Tape).
PF	ACCIPMC	Announced Cooperative class I prices, by selected cities, dollars per cwt., by months.	Dairy Market Statistics: Agricultural Marketing Service, USDA, Annual Summaries, 1977-81c.
PO	CPICPRM	Consumer Price Index: Dairy Products, by selected urban regions, by months.	Bureau of Labor Statistics USDL (Computer Printout).
W	QHEWMi	Average Hourly Earnings of Production Workers on manufacturing payrolls, by states, dollars per hour, by month.	Employment and Earnings: Bureau of Labor Statistics USDL, 1977-81.
	POPji	Population of Federal Milk Marketing Areas, by markets, by state, by year.	Federal M. Order Market Statistics: Agricultural Marketing Service - USDA, 1977-81d.
E	EACPKHiY	Energy: Average cost per kilowatt hour, by states, by year, cents per kilowatt hour.	Agricultural Prices: Crop Reporting Service, USDA, 1977-81b.
	POPji	As defined above.	
Y	TPINCi	Total Personal Income, by states, by quarters, mil. dollars.	Survey of Current Business, BEA, USDL, 1977-82.
	POPji	As defined above.	

Table 5. Continued

Variable Name	Data Name	Definition	Source
	POPi	Population, by states, by year, thousands	Regional Economic Information System, Bureau of Economic Analysis, USDC (Computer Printout).
QMD	CCCPBCiY	CCC purchaser of butter and cheese under the dairy support program: Total milk equivalent, by states, by marketing year mil. lbs.	Agricultural Stabilization and Conservation Service - Dairy Division, USDA (Mailed copies).
	CCCREM	Total USDA net removals of equivalent milk, U.S., by quarters, mil. lbs.	Dairy: Outlook and Situation, USDA, 1977-82a.
	GQMPi	Milk Production: total milk produced by states, by quarters, mil. lbs.	Milk Production: Crop Reporting Board, SRS, USDA, 1977-81e.
	PERFEi	Percent of fluid grade sold to plants and dealers, by states, by year.	Milk Production, Disposition and Income: SRS, USDA, 1977-81f.
	QACiY	Milk marketed by producers, sold directly to consumers, by states, by years mil. lbs.	Milk Production, Disposition and Income: SRS, USDA, 1977-81f.
	QARij	Producer deliveries of milk for Federal order marketing areas, by marketing area and state, by year, 1,000 lbs.	Federal Milk Order Market Statistics: Agricultural Marketing Service, USDA, 1977-81d.

Table 5. Continued

Variable Name	Data Name	Definition	Source
	QWMSPDi	Milk sold to plants and dealers, by states, by year, mil. lbs.	Milk Production, Disposition and Income: C.R.B., SRS, USDA, 1977-81f.
	QCZjM	Producer milk used in class 2 by handlers regulated under Federal milk orders, by Federal markets, by months, 1,000 lbs.	A.M.S., USDA (Computer Tape).
	QARjM	Receipts of milk from producers by handlers regulated under Federal milk orders, by Federal markets, by months.	A.M.S., USDA, (Computer Tape).
PM	PC2jM	Class 2 prices per cwt. established by Federal milk orders for milk of 3.5 percent butterfat content, by Federal order markets, by months, dollars per cwt.	A.M.S., USDA, (Computer Tape).
	PC3jM	Class 3 prices per cwt. established by Federal milk orders, for milk of 3.5 percent butterfat content, by Federal order markets, by months, dollars per cwt.	A.M.S., USDA, (Computer Tape).
	QC2jM	As defined above.	
	QARjM	As defined above.	
	QC1jM	As defined above.	

Table 5. Continued

Variable Name	Data Name	Definition	Source
POM	CPIDPRM	As defined above.	
WM	AHEWMi	As defined above.	
EM	EACPKHiY	As defined above.	
	POPji	As defined above.	
QA	GQMPi	As defined above.	
	PERFEi	As defined above.	
	QACiY	As defined above.	
	QWMSPDi	As defined above.	
PA	PRFFEiM	Prices received by farmers for milk sold to plants, eligible for fluid market, by states, by months.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.
PB	PRFMMiM	Prices received by farmers for milk sold to plants, manufacturing grade, by states, by months.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.
C	NCOWSAiQ	Milk cows: Number, by months, by states, thousands.	Milk Production: CRB, SRS, USDA, 1977-81e.
PDF	DFP16Pi	Dairy feed, sixteen percent protein. Price paid by farmers, by states, by months, dollars.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.
PMC	MCPRFiM	Milk cows, price received by farmers, by states, by months, dollars per head.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.

Table 5. Continued

Variable Name	Data Name	Definition	Source
QB	GQMPi	As defined above.	
	PERFEi	As defined above.	
	QACiY	As defined above.	
	QWMSPDi	As defined above.	
FW	FWRi	Farm wage rate, all hired farm workers, by states, by selected periods in the year, dollars per hour.	Farm Labor: Crop Reporting Board, SRS, USDA (Official mailed copies).
PC	CPQFiM	Cows: Price received by farmers, by states, by months, dollars per cwt.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.
E	EACPKHiY	As defined above.	
DDEF	PPIFFP	Producer Price Index: Food and Feeds, processed, U.S., by months, 1967 = 100.	Survey of Current Business: (USDL Indexes), 1977-81.
SDEF	IPRFAFP	Index of prices received by farmers, all farm products, U.S., by months, 1977 = 100.	Agricultural Prices: CRB, SRS, USDA, 1977-81b.

With respect to the stability of the Federal Marketing Order system, it was observed that the number of orders have been changing frequently. The only period of time that it remained relatively unchanged was 1977-1980. However, the period can be extended to 1981 because the sole order added to the system can be easily isolated.

Two changes in the price support program that are likely to shift the sensitivity of the industry participants occurred in the decade of the 1970's. Starting in 1973, the supporting price level for manufacturing milk became semi-annually adjusted. The second change is that in September 30, 1977, the milk marketing year was changed to October 1-September 30, instead of April 1-March 31. The above reasons led to the choice of 1977 to 1981.

Unit of Time

The quarter (one-fourth of a year) was the choice for the unit of time. Two reasons weighed heavily upon this selection. One is the biological and regulated characteristics of the dairy industry. The lag between price changes and production response is certainly larger than a week, or even a month. Milk production is a continuous productive process that cannot be interrupted or altered in a very short period of time. On the other hand, important variations in production (through cow feeding controls), due to short-run movements of prices, would not be captured if annual data were used. Moreover, quarters are preferred over annual or semestral data due to the necessity of obtaining

sufficient degrees of freedom in the estimation of the models. Recall that the period of analysis covers only five years.

The second reason is due to the fact that the frequency of Milk Production issued by the Crop Reporting Board, USDA, as well as some other government statistical reports of interest to the dairy industry, shifter from monthly to quarterly publications in the second quarter of 1982. This gives an advantage for the use of quarterly information if the model were eventually considered for updatings.

Cross-Sectional Units

The main reason for considering pooling techniques in the estimation of the empirical models was its ability to combine available information from cross section with available time series data in a statistical model.

Marketing Order areas fit into the desired patterns for cross-sectional units on the demand side. They are delineated to cover important consumer areas and are geographically defined. State marketing orders will not be considered as a cross-sectional unit in the estimation of the demand functions. The reason is that, in general, they also establish a ceiling price for dairy products in addition to the minimum price normally set as in the Federal Order system.

The state is considered a natural selection to be the cross-sectional unit in the estimations of both supply functions. Statistics are adequately available at this level.

There are 45 cross-sectional units in the estimation of the derived demand functions for fluid milk and 41 for manufacturing milk. The Neosho Valley Federal Order statistics were not of acceptable quality. The states of Delaware, Montana, New Hampshire, New Mexico, Nevada, Rhode Island, South Carolina, West Virginia and Wyoming were not included in the supply estimations because statistics with respect to the price of fluid milk were not published. Twenty-five states were grade B milk producers. All entered the estimations.

Model Specification

Derived Demand Functions

Difficulties exist, in applied work, in determining the correct functional form of theoretical relationships. The criteria adopted are to select the specification which yields the expected sign for the price coefficients and reasonable levels of significance for the "t" statistics. The derived demands for fluid eligible milk and manufacturing milk in the log-log, or double log, functional form can be written as

$$(4.7) \quad \log QF_{jt} = \log a_0 - \sum_{r=1}^{9} a_r R_r \log PF_{jt} + a_{10} \log PO_{jt} - a_{11} \log W_{jt} - a_{12} \log E_{jt} + a_{13} \log Y_{jt} \pm a_{14} S_1 \pm a_{15} S_2 \pm a_{16} S_3 + U^F_{jt}$$

$$(4.8) \quad \log QMD_{jt} = \log b_0 - \sum_{r=1}^{2} b_r R_r \log PM_{jt} - \sum_{r=4}^{9} b_r R_r \log PM_{jt} + b_{10} \log POM_{jt} - b_{11} \log WM_{jt} - b_{12} \log EM + b_{13} \log Y_{jt} \pm b_{14} S_1 \pm b_{15} S_2 \pm b_{16} S_3 + U^M_{jt}.$$

where all variables are defined in Table 1. Note that $t = (1,2,\ldots,20)$ refers to a given quarter, starting with the first quarter of 1977; $j = (1,\ldots,45)$ refers to a cross-sectional unit (in this case, Federal Order Milk market); $s = (1,2,3)$ refers to the first, second, and third quarters of each year (S_4 is not included); $r = (1,\ldots,9)$ refers to the nine U.S. census regions (modified).

The random errors U^F_{jt} and U^M_{jt} are assumed to have zero mean and constant variance. All coefficients are assumed to be constant over time, but the price-slope of both functions may differ for each region. Total personal income, Y, was included to shift the intercept across cross-sectional units and across time.

Supply Function for Grade A Milk

The same criteria adopted in the demand functions with respect to the choice of the functional form of the variables are followed here. Primarily the best adjustment will be chosen when the estimated coefficients of the price variables have the expected sign followed by reasonable levels of significance for the "t" statistics. The supply function for grade A milk specified in the linear form of the variables is

$$(4.9)\quad QA_{it} = c_o + \sum_{r=1}^{9} c_r R_r PA_{it} + c_{10}PA_{t-1} + \ldots + c_{13}PA_{t-4} + c_{14}PA_{t-13} + \ldots + c_{17}PA_{t-16} - c_{18}PB_{t-1} + c_{19}PMC_{it} - c_{20}PDF_{it} + c_{21}C_{it} \pm c_{22}\, S_1 \pm c_{23}\, S_2 \pm c_{24}\, S_3 + U^A_{it}$$

where all the variables are defined in Table 1. Here, i = (1,...,39), refers to a state producing and selling fluid eligible milk; t = (1,..., 20) refers to a quarter within the period 1977-1981; S_4 is not included to keep the full rank of the matrix formed with observations for the explanatory variables. The random error U^A_{it} is assumed to have zero mean and constant variance.

Supply and Demand Functions for Grade B Milk

The supply and demand functions for grade B milk at the farm level, if specified in the linear form of the variables, can be written as equations 4.10 and 4.11 below

$$(4.10)\quad QB_{it} = d_0 + d_1PB_{it} - d_2PA_{it-1} - d_3PA_{it-2} - d_4PDF_{it} - d_5FW_{it} + d_6PC_{it} - d_7E_{it} \pm d_8S_1 \pm d_9S_2 \pm d_{10}S_3 \pm \sum_{u=11}^{5} d_u ZSB_u + U^{SB}_{it} ;$$

$$(4.11)\quad PB_{it} = e_0 - e_1QB_{it} + e_2Y_{it} \pm \sum_{s=3}^{5} e_s S_s \pm \sum_{u=6}^{30} e_u ZDB_u + U^{DB}_{it}.$$

All variables definitions can be found in Table 1. Here, i = (1,...,25) refers to the grade B milk producing state; t = (1,...,20) refers to each quarter within the period 1977-1981; s = (1,2,3) refers

to the first, second, and third quarters of each year. Again, S_4 is not included in the model to avoid the "dummy trap." The sub "u" identified the cross-sectional unit that is shifting the intercept. The random error for the i^{th} state and t^{th} period is U_{it}^{SB} for the supply function and U_{it}^{DB} for the demand function.

Choice of the Estimators

As all coefficients in equations 4.7 through 4.11 are assumed to be fixed parameters, the appropriate estimation technique is the "covariance model" [Judge, 1982, p. 477].

The parameters of the equations 4.7, 4.8 and 4.9 do not change across time, but only across groups of individuals. For such cases, it is convenient to write each individual ordinary least squares equation as

$$(4.12) \quad Y = Z\Psi + W\beta + \varepsilon$$

where

$Y' = (Y_1', Y_2', \ldots, Y_n')$ is a (1xNT) vector of observations on the dependent variable,

$$Z = \begin{bmatrix} X_1 & & & \\ & X_2 & & \\ & & \ddots & \\ & & & X_r \end{bmatrix}$$

is an (NTxR) block diagonal matrix of observations on the explanatory variables. Each block X_r containing TK_r observations and 1 explanatory

variable. T is the time series length and K_r is the number of cross-sectional units included in each region r, and $\sum_{j=1}^{r} K_j = N$.

$W = [X_{r+1},\ldots,X]$ is a (NTxG) matrix of observations on the remaining $G = m - r$ explanatory variables. $\Psi' = (\Psi'_1,\ldots,\Psi'_r)$ is a (1xR) vector of unknown fixed parameters to be estimated, $\beta' = (\beta'_{r+1},\ldots,\beta'_m)$ is another (1xG) vector of unknown fixed parameters to be estimated. The disturbance vector is the (1xNT) vector ε. The least square estimator is used in their estimation.

Again, note that all explanatory variables in the right-hand-side of equations 4.7, 4.8, and 4.9 are either exogenous or pre-determined variables. With respect to the exogeneity of PA in equation 4.9 it can be argued that empirically it seems that every dairy farmer knows, if not exactly, the approximate marketing price for grade A milk. This situation is due to the regulatory devices prevailing in the dairy market. The government directly fixes a minimum price for class I, II, and III, that plants must pay for grade A milk. This situation is diametrically contrasted with the grade B milk market. There the government fixes no minimum price for crude milk. The price paid by plants is determined by bargaining between plants and producers. The joint dependence between QB and PB therefore arises, and the relationships depicted by equations 4.10 and 4.11 require a simultaneous system approach. Three stage least squares was chosen as estimator in such cases.

Econometric Estimations

Empirical estimations were performed with the sampled data described earlier using the models discussed in the preceding section. Concerns about serial correlation were raised. Maddala [1977, p. 332] suggests that "in all problems of pooling, it is important to estimate each equation (for each cross-sectional unit) individually by OLS and check whether there is . . . a systematic pattern in the residuals."

Accordingly, demand and supply equations were estimated for several cross-sectional units, randomly selected from each region. The first-order autoregressive disturbance coefficients and the Durbin-Watson statistics obtained from these estimations were used to test the null hypothesis of autocorrelation in the residuals. In all but a few cases the Durbin-Watson test was inconclusive and the Rho was not statistically different from zero. In addition it was postulated that the inclusion of size variables in the models, which is supposed to appropriately shift the intercept coefficients, could reduce the mutual correlation across cross-sectional units, if it exists, and by so, lessening the variance-covariance of the regressors' coefficients.

Results for the Fluid Milk Derived Demand Function

The parameter estimates, their respective standard errors, and the area in both tails of the "t" distribution, are given in Table 6. All estimates have the expected sign and are statistically different from zero.

Table 6. Derived Demand for Fluid Milk

Variable Name	Parameter Estimate[a]		Probability > |t|[b]
	Value	Std. Error	
Intercept	-4.703593	1.460426	0.0013
log (E)	-0.545483	0.102813	0.0001
log (W)	-1.051312	0.134157	0.0001
log (PO)	0.754648	0.348625	0.0307
log (Y)	1.068963	0.010821	0.0001
S_1	0.040478	0.028843	0.1609
S_2	-0.050054	0.028695	0.0814
S_3	-0.049989	0.028365	0.0784
R_1 log (PF)	-1.410415	0.325982	0.0001
R_2 log (PF)	-1.275090	0.326693	0.0001
R_3 log (PF)	-1.416802	0.324050	0.0001
R_4 log (PF)	-1.386736	0.328909	0.0001
R_5 log (PF)	-1.349424	0.338517	0.0001
R_6 log (PF)	-1.465624	0.343696	0.0001
R_7 log (PF)	-1.227855	0.341189	0.0003
R_8 log (PF)	-1.218363	0.333654	0.0003
R_9 log (PF)	-1.371344	0.319884	0.0001

Dependent variable: Log (QF)
R^2: .94
Degrees of Freedom: 877

Number of cross-sectional units: 45
Number of Periods: 20
Number of Missing Values: 6

[a]The variance-covariance matrix of the estimated coefficients is included in Appendix C.

[b]For "two-tail" test.

The derived demand price elasticity for the entire sample, ξ_F^{ALL}, is calculated by weighing the elasticities estimated for each region, which can be calculated with Table 6 estimates, by the relative quantities of milk sold by each region.

Consider equation 4.13.

$$(4.13) \quad Q = \sum_{r=1}^{9} QF_r$$

where

QF_r is total fluid milk sold to plants and dealers in region r, r = (1,...,9); deriving both terms with respect to PF, and post-multiplying them by PF/Q, it follows that

$$(4.14) \quad \xi_F^{ALL} = \frac{\partial Q}{\partial PF}\frac{PF}{Q} = \sum_{r=1}^{9} \frac{\partial QF_r}{\partial PF}\frac{PF}{Q} = \sum_{r=1}^{9} \frac{\partial QF_r}{\partial PF}\frac{PF}{Q}\frac{QF_r}{QF_r} =$$

$$\sum_{r=1}^{9} \frac{\partial QF_r}{\partial PF}\frac{PF}{QF_r}\frac{QF_r}{Q} = \sum_{r=1}^{9} \xi_F^r \frac{QF_r}{Q}$$

which is the elasticity for all the regions considered.

The regional elasticities, ξ_F^r, are directly derived from Table 1, and the participation of each region in total milk sold to plants, by category, can be found in Table 7.

The calculated elasticity for fluid milk derived demand is -1.195. As expected, this value seems higher than the ones obtained in general from time-series estimations. Coherence for this value can be found by comparing it with the elasticity for manufacturing milk demand. It has been found, in empirical estimations, that the demand functions for

Table 7. Regional Participation in the Total Sales of Fluid and Manufacturing Milk

Region	Federal Milk Orders	QF_r/QF	QMD_r/QM
1	Middle Atlantic New England New York-New Jersey	.2561	.177
2	Louis.-Lex.-Evans. Memphis Nashville Paducah Tennessee Valley	.0551	.030
3	Georgia Southeastern Florida Tampa Bay Upper Florida	.0768	--
4	Central Arkansas Greater Louisiana Lubbock-Plainview Oklahoma Metrop. Red River Valley Texas Panhandle Texas	.1242	.065
5	Central Illinois Eastern Ohio-W. Pa. Indiana Ohio Valley Southern Illinois Southern Michigan	.1960	.123
6	Chicago Regional Michigan Upper Peninsula Upper Midwest	.1128	.410
7	Black Hills Eastern South Dakota Greater Kansas City Iowa Nebr.-Western Iowa St. Louis-Ozarks Wichita	.0826	.103
8	Central Arizona Eastern Colorado Great Basin Lake Mead Rio Grande Valley Western Colorado	.0536	.048
9	Inland Empire Oregon-Washington Puget Sound	.0428	.045

manufactured dairy products are, in general, more elastic than the demand for fluid milk.

Results for the Commercial Derived Demand for Manufacturing Milk

A summary of statistics related to the estimation of the manufacturing milk derived demand function can be found in Table 8. The sample generated estimates have the expected signs. The own-price elasticity for all regions entered the sample is -4.433, which confirms earlier studies suggesting that the demand for manufacturing milk is more elastic than the demand for fluid.

The same procedure used to compute the price-elasticity for the derived demand of fluid milk is followed. The value of -4.433 is found by the formula

$$(4.15) \quad \xi_M^{ALL} = \sum_{r = 1,2,4}^{9} (\xi_M^r \frac{QMD_r}{QMD}),$$

where ξ_M^r are the respective regional elasticities, as in Table 8, and QMD_r/QMD is the share of each regional in the total manufacturing milk marketed (See Table 7).

Results for the Supply of Fluid Eligible Milk

Direct estimations of the supply model for fluid eligible milk generated the coefficients shown in Table 9. All estimates, but one, have the expected sign. The short-run elasticity for the sample is .24, which compares with previous studies. The sample elasticity is calculated by weighing the regional elasticities with the share of each region in the total milk marketed. Consider the equation

Table 8. Derived Demand for Commercial Manufacturing Milk

Variable Name	Parameter Estimate[a] Value	Parameter Estimate[a] Std. Error	Probability > $\lvert t \rvert$[b]
Intercept	-24.097	4.585	0.0001
R_1 log (PM_t)	- 4.787	1.044	0.0001
R_2 log (PM_t)	- 4.798	1.037	0.0001
R_4 log (PM_t)	- 5.422	1.054	0.0001
R_5 log (PM_t)	- 4.579	1.058	0.0001
R_6 log (PM_t)	- 4.264	1.060	0.0001
R_7 log (PM_t)	- 3.897	1.060	0.0003
R_8 log (PM_t)	- 4.540	1.051	0.0001
R_9 log (PM_t)	- 4.324	0.995	0.0001
log (WM)	- 2.414	0.400	0.0001
log (EM)	- 1.617	0.314	0.0001
log (POM)	5.769	1.143	0.0001
log (Y)	1.291	0.032	0.0001
S_1	0.032	0.093	0.7343
S_2	0.097	0.091	0.2862
S_3	0.102	0.089	0.2528

Dependent variable: Log (QMD)
R^2: .78
Degrees of Freedom: 798

Number of cross-sections units: 41
Number of Periods: 20
Number of Missing Values: 6

[a]The variance-covariance matrix of the estimated coefficients are shown in Appendix C.

[b]For "two-tail" tests.

Table 9. Results for the Supply Function of Fluid Eligible Milk

Variable Name	Parameter Estimate[a] Value	Std. Error	Probability > $\lvert t \rvert$[b]
Intercept	-386.869697	108.416943	0.0004
$R_1\ PA_t$	23.129747	17.336259	0.1825
$R_2\ PA_t$	21.467542	17.342780	0.2162
$R_3\ PA_t$	17.177921	17.069764	0.3146
$R_4\ PA_t$	17.859386	17.082939	0.2961
$R_5\ PA_t$	29.279260	17.855512	0.1015
$R_6\ PA_t$	22.889463	17.813721	0.1992
$R_7\ PA_t$	29.520284	17.585396	0.0936
$R_8\ PA_t$	34.075105	17.458464	0.0513
$R_9\ PA_t$	60.988422	17.743970	0.0006
PA_{t-1}	1.157390	20.838406	0.9557
PA_{t-2}	15.231213	20.245071	0.4521
PA_{t-3}	13.845648	19.443746	0.4766
PA_{t-4}	0.220302	16.411409	0.9893
PA_{t-13}	1.526878	12.349326	0.9016
PA_{t-14}	-0.528715	12.647967	0.9667
PA_{t-15}	2.144024	12.653833	0.8655
PA_{t-16}	7.505699	12.238149	0.5399
S_1	26.375066	15.557422	0.0904
S_2	80.297196	19.571041	0.0001
S_3	33.794170	15.953333	0.0345
PB_{t-1}	- 3.571112	2.274581	0.1168
C	3.033228	0.015543	0.0001
PDF	- 1.766716	0.606725	0.0037
PMC	0.187920	0.091559	0.0405

Dependent variable: QA

R^2: .99

Degrees of Freedom: 755

Number of cross-section units: 39

Number of Periods: 20

[a]The variance-covariance matrix for the estimated coefficients is in Appendix C.

[b]For "two-tail" tests.

$$(4.16)\quad QA = \sum_{r=1}^{9} QA_r \;, \; r = (1,\ldots,9).$$

The elasticity for all regions can be calculated as follows

$$(4.17)\quad \xi_A^{ALL} = \frac{\partial QA}{\partial PA}\frac{PA}{QA} = \sum_{r=1}^{9} \frac{\partial QA_r}{\partial PA}\frac{PA}{QA} = \frac{PA}{QA}\sum_{r=1}^{9}\frac{\partial QA_r}{\partial PA}$$

where

PA is the quarterly average price of QA;

QA is the quarterly average quantity of fluid milk produced during the period, $QA = \sum_{r=1}^{9} QA_r$, and

$r = (1,\ldots,9)$ designates a region.

The slope, $\frac{\partial QA_r}{\partial PA}$, for region r, is given by taking the derivative of the aggregate quantity of region r with respect to the price PA. The equation for each region is given by

$$(4.18)\quad \sum_{i=1}^{m} QA_{it} = QA_r = m\hat{C}0 + m\hat{C}_1 PA_t + \ldots + \sum_{i=1}^{m} U^A_{it}$$

where

m is the number of states i in region r, and

$\hat{C}_o, \hat{C}_1,\ldots,\hat{C}_{24}$, are estimates for $c_0, c_1,\ldots,c_{24}$. (See equation 4.9).

Since, $\frac{\partial QA_r}{\partial PA_t} = m\hat{C}_r$, for region r. Using data from the sample and the estimated coefficients from Table 9, the elasticity for all regions can be calculated

$$\xi_A^{ALL} = \frac{5.45}{24781} [8 \times 23.13 + 4 \times 21.47 + 3 \times 17.18 + 5 \times 17.86 + 4 \times 29.28 + 3 \times 22.89 + 5 \times 29.52 + 3 \times 34.08 + 4 \times 60.99] = 0.24$$

Notice that responses of production throughout time seems to confirm the hypothesis that: (a) short-run adjustments are important in milk production; (b) the effects of a price increase tend to deteriorate after a certain span in time; and (c) in the long-run, the effects of price increase are still present, perhaps due to motivated increase in the number of calves. The elasticity of grade A milk supply with respect to a price change in year t-i are

Year	Elasticity
t	.240
t-1	.010
t-2	.130
t-3	.118
t-4	.002
t-13	.013
t-14	-.004
t-15	.018
t-16	.063

The elasticity for the entire period is .59. This elasticity is within the range of results obtained by Halvorson (1958) and Wilson-Thompson (1967).

Results for the Supply and Demand Functions of Grade B Milk

The results of the three stage least squares estimation for the supply and demand functions of grade B milk at the farm level are shown in Tables 10 and 11. In the estimated demand equation, all variables have the expected sign. In the supply side, the coefficient of WF, (farm wage rate) has the wrong sign. However, statistically, it is not different from zero if 90 percent of confidence is desired. (Kwoka, [1977, p. 373] had a similar problem.) Family labor seems to be largely involved in the grade B milk activity. Tradition, or even religious concerns, could isolate production decisions from wage rate variations.

The price elasticity for the supply function of grade B milk is 1.23, which can be computed by a process similar to the one used in the grade A milk supply case, or

$$(4.19)\quad \xi_B^{ALL} = \frac{\partial QB_t}{\partial PB_t}\ \frac{PB_t}{QB_t} = M\hat{d}_1\ \frac{\overline{PB}_t}{\overline{QB}_t^{US}} = 25 \times 52.316 + \frac{4.70}{4983} = 1.23$$

where

M is the number of states;

$\hat{d}_1$ is the estimated coefficient for PB_{it};

$\overline{PB}_t$ and $\overline{QB}_t$ are quarterly average price and quantities for all states in the sample.

This value seems reasonable in view of the estimation technique used which tends, itself, to capture some long-run reactions. Note, meanwhile, that besides difficulties usually found in the estimation of the grade B supply function the sample used revealed that grade B

Table 10. Demand Function for Grade B Milk

Variable Name	Parameter Estimate[a] Value	Std. Error	Probability > $\|t\|$[b]
Intercept	4.175	0.192	0.0001
QB	-0.001	0.001	0.2299
S_1	-0.193	0.029	0.0001
S_2	-0.283	0.043	0.0001
S_3	-0.255	0.030	0.0001
Y_i	0.00005	0.000	0.0001
ZDB_6 (Alabama)	-0.269	0.197	0.1724
ZDB_7 (Arkansas)	0.335	0.176	0.0578
ZDB_8 (California)	-4.507	0.344	0.0001
ZDB_9 (Idaho)	0.983	0.120	0.0001
ZDB_{10} (Illinois)	-1.503	0.155	0.0001
ZDB_{11} (Indiana)	-0.643	0.148	0.0001
ZDB_{12} (Iowa)	0.780	0.248	0.0018
ZDB_{13} (Kansas)	0.311	0.148	0.0363
ZDB_{14} (Kentucky)	-0.027	0.103	0.7975
ZDB_{15} (Michigan)	-1.434	0.168	0.0001
ZDB_{16} (Minnesota)	1.225	0.879	0.1640
ZDB_{17} (Mississippi)	0.242	0.194	0.2114
ZDB_{18} (Nebraska)	0.664	0.093	0.0001
ZDB_{19} (North Carolina)	-0.184	0.186	0.3218
ZDB_{20} (North Dakota)	0.663	0.104	0.0001
ZDB_{21} (Ohio)	-1.483	0.153	0.0001
ZDB_{22} (Oklahoma)	0.169	0.173	0.3295
ZDB_{23} (Oregon)	0.665	0.171	0.0001
ZDB_{24} (Pennsylvania)	-1.499	0.205	0.0001
ZDB_{25} (South Dakota)	1.018	0.127	0.0001
ZDB_{26} (Tennessee)	-0.108	0.133	0.4194
ZDB_{27} (Utah)	0.706	0.144	0.0001
ZDB_{28} (Virginia)	-0.382	0.167	0.0226
ZDB_{29} (Wisconsin)	2.075	1.516	0.1718

Dependent Variable: PB

[a]See corresponding statistics in Table 11.

[b]For "two-tail" tests.

Table 11. Supply Function for Grade B Milk

Variable Name	Parameter Estimate[a] Value	Std. Error	Probability > $\|t\|$[b]
Intercept	338.726	76.29	0.0001
PB	52.316	48.50	0.2812
POF	- 0.958	0.87	0.2726
FW	34.561	31.36	0.2710
PC	- 5.184	2.07	0.0127
PA_{t-1}	-29.366	11.61	0.0118
PA_{t-2}	- 1.759	10.36	0.8653
S_1	38.865	18.25	0.0337
S_2	62.405	17.65	0.0004
S_3	30.220	11.87	0.0113
E_i	-82.413	40.53	0.0426
ZSB_{11} (Alabama)	-131.435	27.00	0.0001
ZSB_{12} (Arkansas)	-130.295	14.09	0.0001
ZSB_{13} (California)	-70.501	18.15	0.0001
ZSB_{14} (Idaho)	5.198	32.49	0.0730
ZSB_{15} (Illinois)	-49.077	15.62	0.0018
ZSB_{16} (Indiana)	-105.290	25.78	0.0001
ZSB_{17} (Iowa)	231.198	12.05	0.0001
ZSB_{18} (Kansas)	-114.927	15.64	0.0001
ZSB_{19} (Kentucky)	-75.890	12.68	0.0001
ZSB_{20} (Michigan)	-87.135	33.04	0.0086
ZSB_{21} (Minnesota)	830.598	14.32	0.0001
ZSB_{22} (Mississippi)	-153.176	14.64	0.0001
ZSB_{23} (Nebraska)	-57.721	13.84	0.0001
ZSB_{24} (North Carolina)	-156.080	13.36	0.0001
ZSB_{25} (North Dakota)	-94.312	16.31	0.0001
ZSB_{26} (Ohio)	-74.186	20.71	0.0004
ZSB_{27} (Oklahoma)	-148.478	12.12	0.0001
ZSB_{28} (Oregon)	-245.133	51.95	0.0001
ZSB_{29} (Pennsylvania)	-142.437	12.57	0.0001
ZSB_{30} (South Dakota)	67.718	18.97	0.0004
ZSB_{31} (Tennessee)	-141.418	19.36	0.0001
ZSB_{32} (Utah)	-140.625	17.97	0.0001
ZSB_{33} (Virginia)	-120.002	16.47	0.0001
ZSB_{34} (Wisconsin)	1457.633	19.57	0.0001

Dependent Variable: QB

Weighted R^2 for the system: .98
DF for the system: 935
Number of periods: 20

Number of cross-sectional units: 25
Number of equations: 2

[a] The variance-covariance matrix for the estimated coefficients is in Appendix C.

[b] For "two-tail" tests.

production has been shrinking, ceteris paribus, due to increases in grade A milk lagged prices.

Equations for the United States Dairy Industry

Equations 4.7, 4.8, 4.9 and 4.10, estimated with data generated by pooling cross-section over time-series, are now converted to represent the behavior of the entire United States dairy industry.

Derived Demand Curve for Fluid Milk in the United States

The equation for the derived demand curve for fluid milk in the United States was assumed to be

$$(4.20) \quad QF^{US} = A_0 \; PF^{AI} \; EXP \; \left(\sum_{s=2}^{4} A_{0,s} S_s \right),$$

where

QF^{US} is total fluid milk demanded by processors in the United States, by quarter;

A_0 is a constant term for the equation;

PF is the price of fluid milk, by quarter;

AI is the price elasticity of -1.195 as derived previously.

The value, A, is determined in order that equation 4.20 is satisfied for the fourth quarter of 1980. Recall that the intercept coefficient for the equations 4.7 through 4.11 are the intercept coefficients (constant terms) for the fourth quarter. Seasonal shifters S_1, S_2, and S_3, for the first, second, and third quarter, respectively, are explicitly introduced. Therefore,

$$(4.21) \quad A_0 = \overline{QF}_t / \overline{PF}^{AI}) = 13097/(5.77)^{-1.195} = 106360, \text{ and}$$

$$A_{0,1} = A_0 \ e^{.040} = 110{,}700;$$

$$A_{0,2} = A_0 \ e^{-.050} = 101{,}172;$$

$$A_{0,3} = A_0 \ e^{-.050} = 101{,}172;$$

where .04, -.05, and -.05 are the estimated coefficients for S_1. S_2, and S_3, respectively, as in equation 4.7. The derived demand curve for fluid milk in the U.S. can, therefore, by represented by

$$(4.22) \quad QF^{US} = 106360 \ PF^{-1.195} \ EXP \ (.04 \ S_1 - .05 \ S_2 - .05 \ S_3).$$

Derived Demand Curve for Commercial Manufacturing Milk in the United States

The derived demand curve for commercial manufacturing milk in the United States is assumed to have the following specifications

$$(4.23) \quad QMD_t^{US} = B0 \ PM_t^{B1} \ EXP \ (\sum_{s=2}^{4} B_{0,s} S_s)$$

where

QMD_t^{US} is total commercial manufacturing milk demanded by manufacturers in the United States, in period t;

PM_t is the price of manufacturing milk in the United States, in period t;

B1 is the elasticity of -4.438, as estimated earlier;

B0 is a constant term for the equation. Its value is determined in order that equation 4.23 is satisfied for the fourth quarter of 1980.

S_s are seasonal intercept shifters, and

B_s are the coefficients for S_s.

Since,

(4.24) $BO = \overline{QMD}_t/(\overline{PM}_t^{B1}) = 15192/(4.82)^{-4.433} = 16,201,770.$

The constant terms BO,1, BO,2, and BO,3, for the first, second, and third quarters, respectively, are

$BO,1 = BO\ e^{.032} = 16728611,$

$BO,2 = BO\ e^{.097} = 17852089,$

$BO,3 = BO\ e^{.102} = 17941573,$

where .032, .097, and .102 are the estimated coefficients for S_1, S_2, and S_3, respectively, as in equation 4.8.

The equation for the derived demand curve of commercial manufacturing milk in the United States can therefore be written as

(4.25) $QMD_t^{US} = 16201770\ PM^{-4.433}\ EXP\ (.032S_1 + .097S_2 + .102S_3).$

Supply Curve for Fluid Eligible Milk in the United States

The supply curve for fluid eligible milk in the United States is assumed to have the following equation

(4.26) $QA_t^{US} = CIPA_t + \sum_{s=2}^{5} C_{0,s}S_s$

where

QA_t^{US} is the quantity of fluid eligible milk supplied in the United States, by quarter;

PA_t is the price received by farmers for fluid eligible milk sold in the United States, by quarter;

C1 is the value for the U.S. price coefficient. It is calculated by multiplying the number of states entering each region, by its respective estimated price coefficient, that is

$$(4.27)\quad \frac{\partial QA_t^{US}}{\partial PA_t} = \sum_{r=1}^{9} \frac{\partial QA_r}{\partial PA_t} = [11 \times 23.13 + 4 \times 21.47 + 4 \times 17.18 + 5 \times 17.86 + 5 \times 29.28 + 3 \times 22.89 + 5 \times 29.52 + 7 \times 34.08 + 4 \times 60.99] = 1684.$$

C_0 is the intercept for the above equation. Its value is determined so that the fluid eligible milk supply curve for U.S. is solved for the fourth quarter of 1980. Since,

$$(4.28)\quad C0,4 = \overline{QA}_t^{US} - C1\overline{PA}_t = 25276 - 1684 \times 5.39 = 16200.$$

The above intercept is shifted by the seasonal variable S_s, as included in equation 4.9. The intercepts C0,1, C0,2, and C0,3, for the first, second, and third quarters, respectively, are

$$C0,1 = C0,4 + n\,\hat{C}10 = 16200 + 48 \times 26.37 = 17466;$$

$$C0,2 = C0,4 + n\,\hat{C}11 = 16200 + 48 \times 80.30 = 20055;$$

$$C0,3 = C0,4 + n\,\hat{C}12 = 16200 + 48 \times 33.79 = 17822$$

where 26.37, 80.30, and 33.79 are the estimated coefficients for S_1, S_2, and S_3, respectively, as in equation 4.9. The equation for the United States supply curve of fluid eligible milk can thus be written as

$$(4.29)\quad QA_t^{US} = 1684\, PA_t + 17466\, S_1 + 20055\, S_2 + 17822\, S_3 + 16200\, S_4.$$

<u>Supply Curve for Grade B Milk in the United States</u>

Assume that the equation for the grade B milk supply curve in the United States is

$$(4.30)\quad QB_t^{US} = D1PB_t + \sum_{s=2}^{5} D_{0,s}S_s$$

where

QB_t^{US} is grade B milk sold to plants and dealers in the United States, by quarters;

PB_t is manufacturing grade milk price, United States, by quarters;

D1 is the estimated value of 1413, as derived previously;

D_0 is the intercept for the above equation, where value is derived by solving that equation for the average quantity and price values for the fourth quarter of 1980. The solution is

$$(4.31)\quad D0 = \overline{QB}_t - D1\ \overline{PB}_t = 48.5 - 25 + 52.32 \times 4.92 = -1620.$$

The intercepts for the first, second, and third quarters, D0,1, D0,2, and D0,3, respectively, are

$$D0,1 = D0 + n\ \hat{d}_8 = -1620 + 25 \times 38.87 = -649;$$

$$D0,2 = D0 + n\ \hat{d}_9 = -1620 + 25 \times 62.41 = -60;$$

$$D0,3 = D0 + n\ \hat{d}_{10} = -1620 + 25 \times 30.22 = -865;$$

where 38.87, 62.41, and 30.22, are the estimated coefficients for S_1, S_2, and S_3, respectively, as in equation 4.10.

The equation for the supply curve of grade B milk for the United States can therefore be written as

$$(4.32)\quad QB_t^{US} = 1308\ PB_t - 649\ S_1 - 60\ S_2 - 865\ S_3 - 1620\ S_4.$$

The Blend Price Curve

A simplified way of writing the blend price formula is

(4.33) $PA_t = f_{o,t} + f_{1,t}/QA_t$, where

$f_{o,t} = PM_t$, and

$f_{1,t} = (PF_t - PM_t)\ QF_t$.

Setting this equation for the values of $f_{o,t}$ and $f_{1,t}$ when t is the fourth quarter of 1980, results

(4.34) $PA = 4.82 + 12442/QA$, because

$f_{o,t} = 4.82$, and

$f_{1,t} = (4.77 - 4.82)\ 13097 = 12442$.

Summary

All the equations necessary to describe the interface between dairy plants and milk producers are estimated. Adjustments were made to conform the estimated price slope coefficient to the national level. The technique used in the estimations, "pooling" cross-sections over time-series, seems to have compensating results. In general, the estimated equations show adequate explanatory power and the level of significance of most of the coefficients is high. The elasticities may seem larger than normal standards. However, it should be recalled that the "pooling" technique may implicitly be capturing some long-run adjustments. "Given that cross-section data tend to show the long-run, static equilibrium behavior and that time-series data tend to show short-run, it is not at all clear what pooled cross-section and time series data will represent" [Cassidy, 1981, p. 83].

Overview

The estimated equations for (a) derived demand function for fluid milk; (b) derived demand function for commercial manufacturing milk; (c) supply function for grade B milk; and (d) supply function for fluid eligible milk, described in this chapter were used to derive respective equations for the United States, which, in turn, will be used to solve, under certain conditions, the model formulated in Chapter III. Chapter V details the phases of such solutions, the adjustment of the estimated equations for the period, 1979-81, and its application to the research's primary problem which is the simulation of alternative coordinating arrangements to reduce surpluses of milk in the United States.

CHAPTER V
ALTERNATIVE COORDINATING ARRANGEMENTS TO REDUCE MILK SURPLUSES IN THE UNITED STATES

Introduction

The subject of this chapter is centered on simulation of alternative coordinating arrangements to reduce milk surpluses in the United States. It is expected that results from these simulations may diminish uncertainties in the dairy subsector if the simulated changes were, eventually, considered by policy makers or dairy producers organizations. The fourth quarter of 1980 is selected as the simulations' basis.

The derived demand curves for fluid and manufacturing milk and the supply curves for grade A and grade B milk obtained from "pooling cross-section over time-series" data, are used in this chapter to solve the model described in Chapter III. The adjustment of the equations are checked by comparing predicted variables against actual values for the period 1979-1981.

Model Adjustment

The derived demand for fluid and manufacturing milk curves, as well as the supply for grade A and grade B milk curves, obtained in

Chapter IV, compose the simulator, which, along with the quantity and price conditions, are rewritten below.

Demand functions.

(5.1) $QF = 106360\ PF^{-1.195}\ EXP\ (.04\ S_1 - .050\ S_2 - .050\ S_3)$: Equation for the derived demand curve for fluid milk in the United States;

(5.2) $QMD = 16201770\ PM^{-4.433}\ EXP\ (.032\ S_1 + .097\ S_2 + .102\ S_3)$: Equation for the derived demand curve for commercial manufacturing milk in the United States.

Supply functions.

(5.3) $QA = 1684\ PA + 17466\ S_1 + 20055\ S_2 + 17822\ S_3 + 16200\ S_4$: Equation for the supply curve of fluid eligible milk in the United States.

(5.4) $QB = 1308\ PB - 649\ S_1 - 60\ S_2 - 865\ S_3 - 1620\ S_4$: Equation for the supply curve of grade B milk in the United States.

Quantity conditions.

(5.5) $QII \equiv QA - QF$: Grade A milk not used in the processing of fluid products and is used in the manufacturing of dairy products;

(5.6) $QMS \equiv QB + QII$: The available supply of manufacturing milk is composed of grade B and class II milk.

(5.7) $QS \equiv QMS - QMD$: Government removes all excess supply of manufacturing milk from commercial markets.

Price conditions.

(5.8) $PF \equiv PI + PR$: Price of fluid milk is composed of the minimum order price plus cooperative announced premium.

(5.9) $PA \equiv \underset{(f_o)}{4.82} + \underset{(f_1)}{12442}/QA$: Blend price function for the fourth quarter of 1980.

The values for the coefficients of equation 5.9 for all quarters in the period 1977-1981 are given in Table 12.

Results

The simulator described in the last section is now used to predict the values for

QF_t: Quantities purchased by processors of fluid eligible milk in the United States, by quarters, in the period 1979-1981;

QMD_t: Quantities of milk purchased by manufacturers in the United States, by quarters, in the period 1979-1981;

QA_t: Quantities of fluid eligible milk sold by plants and dealers in the United States, by quarters, in the period 1979-1981;

PA_t: Price received by farmers for fluid eligible milk, in the United States, by quarters of 1979-1981; and

QB_t: Quantities of grade B milk sold to plants and dealers in the United States, by quarters of the period 1979-1981.

The predicted values for the above variables, as well as their actual values, are shown in Table 13.

Table 12. Quarter Coefficients for the Blend Price Curve: 1977-81

		First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1977	f_0	4.53	4.53	4.69	4.72
	f_1	18250	14174	15241	15021
1978	f_0	4.60	4.54	4.70	4.93
	f_1	15272	13820	12902	12185
1979	f_0	4.80	4.78	4.94	4.94
	f_1	14840	13589	12588	14469
1980	f_0	4.81	5.05	4.83	4.82
	f_1	16128	12792	12055	12442
1981	f_0	4.96	5.09	5.02	5.03
	f_1	14722	12633	12707	14788

Note that QA_t and PA_t are derived by the solution of equations

(5.10) $QA_t = 1684\ PA_t + 17466\ S_1 + 20055\ S_2 + 17822\ S_3 +$

$16200\ S_4$, and

(5.11) $PA_t = f_{0,t} + f_{1,t}/QA_t$,

where $f_{0,t}$ and $f_{1,t}$ assume the values given in Table 12 for each quarter.

It was observed that the estimated seasonal coefficients for the grade B milk supply curve were performing poorly when compared to the other equations. The equation written as

(5.12) $QB_t = 1308\ PB_t - 1651\ S_1 - 1462\ S_2 - 1158\ S_3 - 1620\ S_4$

improves the adjustments of the curve. The seasonal coefficients are here estimated by solving for the correspondent quantity and price values for the first, second, third and fourth quarters of 1980. Since, applying $D_{0,s} = QB^{0,5} - C1\ PB_1$, for $s = (1,\ldots,4)$ of 1980. The coefficients $D_{0,1}$, $D_{0,2}$, $D_{0,3}$, and $D_{0,4}$ were obtained

$D_{0,1} = 4850 - 1308 \times 4.97 = -1651$,

$D_{0,2} = 5287 = 1308 \times 5.16 = -1462$,

$D_{0,3} = 5003 - 1308 \times 4.71 = -1158$, and

$D_{0,4} = 4815 - 1308 \times 4.92 = -1620$.

Notice that although the demand and supply curves have been set to solve only for the fourth quarter of 1980 values, the model seems to have a reasonable ability in tracking actual values for other quarters within the period 1979-81. The simulator was even able to generate the expected excess supply of manufacturing milk, which, being a residual value, incorporates the errors committed in the estimation of all

Table 13. Predicted Versus Actual Values, U.S., Period: 1979-1981, by Quarters

		QF_t (Mil. lbs.)			$QMD_t^{f/}$ (Mil. lbs.)			QA_t (Mil. lbs.)			PA_t ($ per cwt.)			QB_t (Mil. lbs.)		
Year	Quarter	Actual[a]	Predicted	Difference in Percentage	Actual[b]	Predicted	Difference in Percentage	Actual[c]	Predicted	Differenc in Percentag	Actual[d]	Predicted	Difference in Percentage	Actual[e]	Predicted	Difference in Percentage
1979	1	13286	13273	0.09	15133	15978	- 5.58	24206	26477	-9.38	5.04	5.35	-6.15	4611	4628	-0.36
	2	12412	12205	1.67	16903	17369	- 2.76	26661	28879	-8.32	4.79	5.24	-9.40	5078	4790	5.67
	3	12358	11985	3.02	17626	15086	14.41	25266	26905	-6.49	5.07	5.39	-6.31	4813	5304	-10.20
	4	13335	12303	7.74	14106	13623	3.42	24196	25446	-5.17	5.49	5.50	-0.25	4609	4841	-5.04
1980	1	13055	12958	0.74	17342	15831	8.71	25461	26559	-4.13	5.50	5.41	1.64	4850	4641	4.32
	2	12263	11657	4.94	15570	13614	12.56	27759	29262	-5.42	5.60	5.47	2.27	5287	5143	2.72
	3	12435	12407	0.23	16259	16670	- 2.53	26264	26706	-1.68	5.17	5.28	-1.93	5003	5160	-3.14
	4	13097	13097	0.00	15192	15192	0.00	25276	25149	0.50	5.39	5.31	1.30	4815	4684	2.72
1981	1	12819	12830	-0.09	14548	13816	5.05	26767	26715	0.19	5.40	5.50	-1.83	4724	4837	-2.39
	2	12202	11589	5.03	16236	13147	19.03	29008	29318	-1.07	5.29	5.51	-4.09	5119	5195	-1.49
	3	12210	11749	3.77	16366	14049	14.16	27312	27036	1.01	5.49	5.47	0.31	4820	5408	-12.21
	4	12946	11996	7.34	15978	12575	21.30	26401	25601	3.03	6.04	5.60	7.30	4659	4959	-6.44

[a]Source: Federal Milk Marketing Order Statistics: Annual Summary, AMS, USDA.

[b]Source: Dairy Outlook & Situation, SRS, USDA.

[c]Source: Milk Production, CRB, SRS, USDA.

[d]Source: Agricultural Prices, CRB, SRS, USDA, Annual Summaries; Deflator is Index of Price Received Farmers, All Farm Products (IPRFUSQ).

[e]Source: Milk Production, CRB, SRS, USDA.

[f]Source: Production of factory products, total milk equivalent, net of milk equivalent removed by CC

functions in the model. The diversity of data sources used, errors in proxying the variables, and errors committed in adjusting the estimated functions to the national level are the primary causes of the observed divergences. However, predicting is not the model's primary objective, but rather the simulation of alternatives to reduce milk surpluses. For this purpose, the fourth quarter of 1980 is selected as the simulator basis.

Simulations

Solution for the Basis

The model is first solved for the fourth quarter of 1980, the "basis", to which results of subsequent simulations will be compared (Table 14).

Self-Regulation Alternatives

The following alternatives assume that the dairy industry captures the signals with respect to the amount of purchases of equivalent milk the government is desiring th cut off. No further action is taken by the government. The dairy subsector coordinates itself to produce the quantities of milk just sufficient and necessary to meet the commercial demand and government announced removals. The options for the subsector reside on either the use of authoritative or comprehensive coordination, or price control mechanisms.

Table 14. Simulation Results

		Self-Regulation		Government Controls			
	Basis	Authoritative Production Restriction	Cooperative Price Control	Product Differentiated Support Price	Taxing Output: Without Production Reduction	Taxing Output: With Production Reduction	Selective Support Levels
Grade A Milk Supply	$QA_o = 25149$	$QA_1 = 24763$	$QA_2 = 24763$	$QA_3 = 24763$	$QA_4 = 25149$	$QA_5 = 24763$	$QA_6 = 25119$
Non-fluid Utilization	$QII_o = 11666$	$QII_1 = 11666$	$QII_2 = 11666$	$QII_3 = 11666$	$QII_4 = 12052$	$QII_5 = 11666$	$QII_6 = 12022$
Fluid Milk Demand	$QF_o = 13097$	$QF_1 = 13097$	$QF_2 = 13097$	$QF_3 = 13097$	$QF_4 = 13097$	$QF_5 = 13097$	$QF_6 = 13097$
Grade B Milk Supply	$QB_o = 4684$	$QB_1 = 4684$	$QB_2 = 4684$	$QB_3 = 4684$	$QB_4 = 4684$	$QB_5 = 4684$	$QB_6 = 4633$
Manufacturing Milk Demand	$QMD_o = 15192$	$QMD_1 = 15192$	$QMD_2 = 15192$	$QMD_3 = 15192$	$QMD_4 = 15192$	$QMD_5 = 15192$	$QMD_6 = 15752$
Manufacturing Milk Supply	$QMS_o = 16736$	$QMS_1 = 16350$	$QMS_2 = 16350$	$QMS_3 = 16350$	$QMS_4 = 16736$	$QMS_5 = 16350$	$QMS_6 = 16654$
Government Removals	$QS_o = 1544$	$QS_1 = 1158$	$QS_2 = 1158$	$QS_3 = 1158$	$QS_4 = 1544$	$QS_5 = 1544$	$QS_6 = 902$
Blend-price	$PA_o = 5.315$	$PA_1 = 5.322$	$PA_2 = 5.085$	$PA_3 = 5.085$	$PA_4 = 5.085$	$PA_5 = 5.085$	$PA_6 = 5.297$
Manufacturing Milk Price	$PM_o = 4.820$	$PM_1 = 4.820$	$PM_2 = 4.820$	$PM_3 = 4.820$	$PM_4 = 4.820$	$PM_5 = 4.820$	$PM_6 = 4.781$
Fluid Milk Price	$PF_o = 5.770$	$PF_1 = 5.770$	$PF_2 = 5.770$	$PF_3 = 5.770$	$PF_4 = 5.770$	$PF_5 = 5.770$	$PF_6 = 5.770$
Cooperatives Cash Retention			$58.688				
Manufacturing Milk Price for Grade A Milk				4.32			
Decrease in Grade A Producer's Revenue		$18.78		$77.47	$57.84	$18.78	$6.12
Decrease in Grade B Producer's Revenue							$4.27

Quantities are in million pounds.

Prices are in dollars per hundredweight (1967 dollars).

Revenues in millions of dollars (1967).

Non-price mechanism: restricting milk production. Suppose that through authoritative coordination a production quota is imposed upon grade A dairy farmers in such a way that the government intended cut offs in equivalent milk purchases is accomplished. Suppose that government wants to reduce its purchases by one-fourth. That is, the government announces it will not buy quantities in excess of 1158 million pounds of equivalent milk at the announced support price of $4.82. The corresponding quota on the grade A milk production is 24763 million pounds, since a reduction of 386 million pounds is necessary. The price received by farmers for each hundred pounds of grade A milk will be $5.322 which is higher than the price before the quota. Even so grade A farmers would see their revenue being reduced by $18.78 million, in 1967 values, which corresponds to a loss of $47.86 million in terms of 1980 values. This solution is shown in the second column of Table 14.

Price-mechanism: cooperative price control. Producer cooperatives are responsible for marketing most (92 percent) of the milk sold to processors who are regulated by milk marketing orders [Cook and Hayenga, 1981, p. 16]. Suppose that these organizations are eligible to retain, at least temporarily, part of the returns obtained from milk sales. The cooperatives self-coordination rule is to pay producers only the price that will generate a volume of production to satisfy commercial demands and limited government purchases.

Assume, again, for further comparative purpose, that the government is limiting its purchases of equivalent milk to QS2 = 1158 million

pounds. The price that cooperatives should pay grade A farmers is PA2 = \$5.085 per hundredweight, which is the solution of the equation

(5.13) PA2 = (QA2 - 16200/1684)

for QA2, which is 24763.

The remaining equilibrium values for this solution can be seen in the third column of Table 14. Note that the cooperatives existence allows a new element of coordination to enter the model, without needing government direct control. The cooperatives would retain cash values, in this case around \$58.688 million (PA1 - PA2) QA2.

Alternative Government Controls

If the dairy subsector is not able to coordinate itself in order to reduce milk production, the route is open for additional government regulations. Alternative policies are searched to enforce the supply side of the dairy subsector to adjust with the desired situation.

Product differentiation support price. Suppose that government is convinced that milk surpluses are due to excess supply of grade A milk and thus decides that products manufactured with grade A milk would have a lower price support. The problem here is to find which price support would be necessary and sufficient to make grade A farmers produce only the amount required by commercial and government outlets. Mathematically, the problem is to find the solution for PM3 in the equation

(5.14) PA3 = PM3 + (PF3 - PM3) QF3/QA3, for the value of PM3,

that is,

(5.15) PM3 = (PA3 X QA3)/QA3 - QF3) = 4.32,

where PA3 = 5.085 is given by the solution of

(5.16) $PA3 = (QA3 - 16200)/1684$, for $QA3 = 24763$.

In this case, if grade A farmers had chosen to reduce production through any of the self-regulation alternatives, they would have saved $58.688 million (1967 prices) because $77.471 would be the reduction in revenue if the presented alternative were chosen, and only $18.611 would be the revenue reduction due to the quota self-imposition (Table 14). It is assumed that the differences between the two supported prices would be collected by the government from the manufacturing plants.

Taxing output. Suppose that a $0.23 checkoff had been levied on every hundred pounds of grade A milk produced. If the checkoff had been previously announced it would be effective only if quantities exceeded 24763 million pounds, an alternative open to grade A milk farmers would be to reduce production to that level. In this case, total loss in revenue would be $(PA0\ QA0) - (PA4\ QA4) = 1878$, that is, $18.78 million.

However, if $QA4 = QA0$ is produced anyway, revenue losses with the checkoffs are $57.843 million (Table 14).

Selective price support levels. Suppose the price support had been set ten cents of a dollar below its fourth quarter of 1980 level. The solution to this alternative which can be seen in Table 14, is more drastic than the former because it involves indiscriminately grade A

and grade B milk production. Revenue losses to the dairy sector would be $10.39 million. Grade A farmers revenue reduction would have been $6.116 million.

Summary and Conclusions

Estimates obtained from "pooling cross-sections over time-series" techniques were used to calculate derived demand curves for fluid and manufacturing milk and supply curves for grade A and grade B milk in the United States. These four equations plus quantity and price conditions identities were the components of an empirical model used to simulate alternative coordinating arrangements to reduce milk surplus in the United States. The transformed equations demonstrate a reasonable predicting power for the period 1979-1981. The fourth quarter of 1980 is selected as the "basis" for the simulations. Results seem to indicate that it would be better for both the government and the private dairy subsector that alternatives labeled as "self-regulations" be selected. Substantial savings in revenue would be realized by farmers if they coordinate themselves to reduce milk surpluses, avoiding additional government supply side regulations.

CHAPTER VI
SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

Summary

Milk production in the United States has exceeded commercial consumption. The consequent volume of milk to be removed, at the prevailing support prices, seems to be above acceptable levels. Three broad strategies to solve this problem are (a) increase commercial consumption, (b) reduce milk production, and (c) increase consumption and reduce production.

Most of the measures designed to increase consumption of domestic milk, such as reduction of imports, increase in exports, promotion and advertising, may reduce stocked surpluses in the short-run, but formation of surplus, the core of the problem, is likely to persist.

The objective of this study was to examine alternative supply side arrangements to reduce milk surpluses in the United States. The model developed in Chapter III was based on the model initially formulated by Kessel [1967] and extended by Ippolito-Masson [1978], and Dahlgran [1980] (see Chapter II). Model modifications included (a) defining the manufacturing milk demand function to include commercial quantities, excluding government purchases, and (b) redefining the purpose, scope, and some equilibrium conditions.

Using information collected from the United States Departments of Agriculture, Labor, and Commerce, derived demand equations for fluid and commercial manufacturing milk (at the Federal Milk Marketing Order level) and grade A and grade B supply equations (at the state level) were estimated using "pooling" techniques. The estimated coefficients were used to compute correspondent equations for the United States. The model, composed of the supply and demand equations plus quantity and price conditions, was used to simulate alternative arrangements that would reduce milk surpluses. The fourth quarter of 1980 was selected as a "basis."

Alternatives to reduce milk production require changes and/or improvements in the coordination between participants in the exchange function, including government. These alternatives can be classified as (a) self-regulation alternatives, and (b) government control alternatives.

The first set is so labeled because it is assumed that the private sector of the dairy industry would maintain the volume of milk removals at acceptable levels by controlling milk production. The second set of alternatives assumes that government needs to enforce milk production reductions.

These alternatives were simulated using the model developed in Chapter III, with coefficients calculated from equations estimated in Chapter IV. Equations for derived demand for fluid and manufacturing milk, and for grade A and grade B milk supply were estimated by pooling sections over time-series data. The price elasticities computed from

the estimated equations are as follows: (a) fluid milk derived demand: -1.195; (b) commercial manufacturing milk derived demand: -4.433; (c) grade A milk supply: .24; and (d) grade B milk supply: 1.23.

Regional elasticities can be calculated for all functions. Supply and demand elasticities appear to be different among regions. In particular, previous studies have reported systematic lack of response of manufacturing milk demand at regional level. This hypothesis was not consistent with the results of this study. The commercial derived demand for manufacturing milk seems to respond to prices at the regional level.

Results from the simulations performed in Chapter V indicate that "self-regulation" should be preferred by milk producers. Government intervention with additional controlling rules would cause further reductions in dairy farmers revenue. It was found that if self-regulation is selected, for every one percent reduction in quantities supplied of grade A milk, dairy farmers' revenue may decrease .51 percent, but if government control is necessary, then for every one percent decrease in quantities marketed of grade A milk, dairy farmers' revenue could decrease by 3.77 percent.

If indiscriminate measures are taken by government, that is, measures affecting both grade A and grade B milk farmers, relatively large decreases in production of grade B milk can be expected. However, for every one percent decrease in quantities supplied of grade B milk, farmers' revenue may decrease only 1.74 percent.

Conclusions

In view of results obtained in Chapter V, it seems that some strategies should be designed by dairy policy makers, from either the government or private sector, in order to motivate dairy farmers to reduce milk production. Additional government rules would further increase dairy farmers' losses in revenue. (Comparisons were made taking fourth quarter of 1980 as basis.) Within these lines it is suggested that immediate actions by government should not be taken. Farmers may need more time to be motivated and to internalize the government restrictions. However, (a) government should demonstrate and reinforce its position with clear figures about the volume of intended purchases, well in advance; and (b) dairy cooperatives' importance as a means of coordination in the dairy subsector should be understood and enhanced. These organizations may be the best channel for communicating the government restrictions to dairy farmers. Dairy cooperatives should help farmers understand the current situation, making clear to dairy farmers that they would be worse off if additional government rules were created to enforce production reductions.

Suggestions for Future Research

Unfortunately, tests for the irreversibility hypothesis in the supply functions of both grade A and grade B did not reveal satisfactory results. Approaches by Tweeten and Quance [1969], Wolffram [1971], Houck [1977], and Traill, Colman, and Young [1978] were unsuccessfully

tried. Even though it is strongly believed that if more time were dedicated to this specific subject, some important results would be obtained. The analysis of a short-run decrease in the price of milk would be enhanced with a non-reversible supply function.

This research could also be empirically extended by simulating the impact of the alternatives examined in this study at the regional level in the context of a regional equilibrium model.

The "pooling" technique seems a reasonable estimation procedure. However, it is suggested that more investigation be dedicated to the seasonality problem and to the price-lagged response of the derived demand functions.

A recent phenomenon in the dairy industry is the utilization of some processing plant facilities for fruit (orange in most cases) price packaging. Derivations of fluid milk demand functions should eventually consider this complementary activity in the processor's profit function.

Another suggestion would be to bring dynamics into the model. The effects over time of alternative arrangements to reduce milk surpluses would bring additional insights into the problem.

Independent cooperatives, as well as "free-riders" (noncooperativated milk producers) could modify the simplified analysis conducted in this study. The extension of their influence could be investigated in further research. However, the government alternatives, analyzed in this study, would, in principle, be imposed upon all milk producers, free-riders, or not. Note that in the current regulated environment (guaranteed milk purchases at the price support level), reduction in

cooperative members' production would not create, itself, any incentive for free-riders to increase theirs.

Finally, the effects of interstate trade of milk cows should be modeled in order that its influence on the lagged price responses could be better understood.

APPENDICES

APPENDIX A
DERIVED DEMAND AND SUPPLY FUNCTION DERIVATIONS

Theoretical Approach

This Appendix has two purposes. The first is to derive, mathematically, using assumptions about the economic behavior of dairy farmers, milk processors and manufacturers, the functions needed to solve the model described in Chapter III. The sec ond objective is to identify explanatory variables for each equation considered in that model. What follows is based on procedures suggested by Varian [1978, pp. 8-34].

Traditionally, the economic behavior of a perfectly competitive firm can be described from its profit maximization objective

$$\text{(A1)} \quad \pi(p) = \max\ p.y \quad \text{s.t. } y \text{ is in } Y$$

where p is a vector of prices for inputs and outputs of the firms; y is either input or output quantities, and Y is the firm's technological possibilities.

The first-order conditions for the single output profit maximization problem when all inputs are used is

$$\text{(A2)} \quad pDf(x^*) = w$$

or

$$\text{(A3)} \quad p\,\frac{\partial f(x^*)}{\partial xi} = wi,\ i = 1,\ldots,n,$$

where $f(x^*)$ summarizes a production function at the levels x^* and y^*.

These conditions say that the value marginal product of each factor must be equal to its price.

The second-order condition for profit maximization is that the matrix of second derivatives of the production function must be negative semi-definite at the optimum set values, that is, the matrix

$$\text{(A4)} \quad D^2f(x^*) = \frac{\partial^2 f(x^*)}{\partial x_i \partial x_j}$$

must satisfy the condition that $hD^2f(x^*)\ h \leq 0$ for all vectors h, which is the same to say that the production function must be locally concave in the neighborhood of an optimum.

For each vector of prices (p,w) there will in general be some optimal choice of factors x^*. The function

$$\text{(A5)} \quad x(p,w)$$

gives the optimal choice of inputs as a function of the prices. This relation is called derived demand function of the firm. Similarly,

(A6) $y(p,w) = f(x(p,w))$ is called the supply function of the firm.

There is an alternative way of finding demand and supply functions which allows an easier discussion of their properties.

Let y(p,w) be the firm's supply function and let xi(p,w) be the firm's demand function for factor i. Then it can be proved [Varian, 1978, pp. 31-32] that

$$\text{(A7)} \quad y(p,w) = \frac{\partial \pi(p,w)}{\partial p}, \text{ and}$$

$$\text{(A8)} \quad xi(p,w) = -\frac{\partial \pi(p,w)}{\partial wi}, \quad i = (1,\ldots,n),$$

when the derivatives exist, and when $w > 0$, $p > 0$.

Now, let xi(w,y) be the firm's conditional factor demand for input i. Then, if c is differentiable at (w,y) and $w > 0$, it can be proved [Varian, 1978, p. 32] that

(A9) $xi(w,y) = \frac{\partial c(w,y)}{\partial wi}$, $i = (1,\ldots,n)$,

Equation (A9) means that the cost-minimizing input vector is just given by the vector of price derivatives of the cost function.

Using equations (A7) through (A9) it can be shown that

(A10) (a): $$\frac{\partial y(p,w)}{\partial p} = \frac{\partial}{\partial p}\left(\frac{\partial \pi(p,w)}{\partial p}\right) = \frac{\partial^2 \pi(p,w)}{\partial p^2}$$

which is non-negative since π is a convex function. Therefore, the supply function slopes upward.

(A11) (b): $$\frac{\partial xi(p,w)}{\partial xi} = \frac{-\partial}{\partial wi}\left(\frac{\partial \pi(p,w)}{\partial wu}\right) = -\frac{\partial^2(\pi(p,w))}{\partial wi^2}$$

which is non-positive since π is a convex function, hence, the demand functions slope downward.

(A12) (c): $$\frac{\partial xj(p,w)}{\partial wi} = \frac{\partial}{\partial wi}\left(-\frac{\partial \pi(p,w)}{\partial wj}\right) = \frac{\partial}{\partial wj}\cdot\left(-\frac{\partial \pi(p,w)}{\partial wi}\right) =$$

$$\frac{\partial xi(p,w)}{\partial wj},$$

That is, the cross-price effects are symmetric, and

(A13) (d): $D^2\pi(p,w)$ is positive semi-definite, since π is a convex function.

Derived Demand Function for Fluid Milk

Using the theoretical framework of the last section, the processor derived demand function for crude milk would be

(A14) $q^{*}f = df\ (pol,\ldots,pox;\ pwl,\ldots,pwz;pf)$

where

QF is the quantity of crude milk used in the processing of fluid milk products;

pf is the price of qf;

poi is the price received for the i^{th} fluid milk product;

pwj is the price of the j^{th} nonmilk input.

It is assumed that the processor is a profit maximizer economic agent in a perfect competitive environment. Equation (A14) gives the quantities of milk demanded at each price, pf, in such a way that the processor could maintain itself at the optimum solution domain. The curve for fluid milk derived demand is downward sloping (equation A11).

Derived Demand Function for Manufacturing Milk

The difference in the profit function between the fluid milk processing plant and the manufacturing milk plant is that the latter may use either fluid eligible or grade B milk, or both, on its productive process. Its restricted profit function is defined as

$$\text{(A15)}\quad \pi_M = \sum_{i=1}^{9} \text{poi qoi} - \sum_{j=1}^{h} \text{pwj qwj} - \text{pm qm}$$

Subject to: $F(\cdot) = F(q0;qw;qm) \geq 0,$

$pm = (pcqc + pBqB)/(qc + qB),$

$qm = qc + qB,$

$qo, qw, qc, qB \geq 0.$

The corresponding derived demand function for manufacturing milk is

(A16) $q^{*}m = qc + qB = dm\ (po;pw;pm)$,

where

qm is the quantity of manufacturing milk used in the production process;

qc is the quantity of fluid eligible milk used in the production of dairy products;

qB is the quantity of grade B milk used in the production process;

po is the vector of prices received for manufactured dairy goods;

pw is the vector of prices paid for the inputs fw, and

pm is the average price of manufacturing milk.

According to equation (A11), the function (A16) is downward sloping.

Supply Functions for Fluid Eligible and Grade B Milk

Assume that a representative dairy farmer produces both fluid eligible and grade B milk. Its restricted profit function can be given by

(A17) $\pi = pAqA + pBqB - pwjqwj$

subject to: $F(\cdot) = F(qA;\ qB;\ qw) = 0$, and

$qA > 0$; $qB > 0$; and $qw > 0$, from where the corresponding supply functions would be derived as

(A18) $q^{*}A = h(pA;\ pB;\ pw)$.

(A19) $q^{*}B = g(pA;\ pB;\ pw)$.

Using equation (A10) it can be concluded that equations (A18) and (A19) are upward sloping functions of their respective prices.

APPENDIX B
GLOSSARY

BLEND PRICE: Is an average of the fluid milk price and manufacturing milk price, weighed by the proportion of milk sold for fluid use and that sold for manufacturing purposes, respectively.

CCC: The Commodity Credit Corporation is the government agency that implements commodity programs.

CLASS I MILK: Is fluid eligible milk processed into fluid milk products such as whole milk (bottled milk), lowfat milk, flavored milk drinks, buttermilk, etc...

CLASS II MILK: Is, in this study, assumed to be any utilization for the fluid eligible milk other than class I use. As such class II milk includes the milk used to manufacture ice cream, sour cream, cottage cheese, yogurt, hard cheeses, butter, evaporated or condensed milk, and dry milk powder.

CLASSIFIED PRICE: Means that the fluid eligible milk is priced according to its utilization (class I, class II, or class III).

CWT: Hundred weight, a measure that corresponds to one hundred pounds.

DAIRY SUBSECTOR: Includes the individuals and firms engaged in milk production, handling, manufacturing, processing, distribution and retailing, as well as the suppliers of needed inputs.

FEDERAL MILK MARKETING ORDERS: This is a legal instrument issued by the Secretary of Agriculture, as authorized by the Agricultural Marketing Agreement Act of 1937 as amended, which regulates the handling of milk in specific marketing areas. Each milk marketing order sets forth minimum prices that handlers must pay producers or assocations of producers according to the way the milk is used.

FIRST HANDLERS: First recipient of grade A milk from producers regulated under Federal Milk Order Markets.

FLUID ELIGIBLE MILK: Is the milk that can be used for consumption in fluid form (most grade A milk).

FLUID MILK PROCESSING PLANT: This is a plant which processes fluid milk products.

GRADE A MILK: Is fluid eligible milk. This grade of milk is produced under conditions which meet sanitary and health requirements of state and local authorities for consumption in fluid form. Grade A milk can also be used in manufactured products.

GRADE B MILK: This grade of milk does not meet grade A requirements, but does meet the requirements for use in manufactured products. It cannot be used for fluid products.

HANDLER: A handler refers to a plant or marketing organization which is regulated under the terms of an order.

HARD MANUFACTURING PRODUCTS: Cheese, butter, nonfat dry milk, and canned milk.

MANUFACTURERS: Refers to a concern primarily engaged in making so-called hard dairy products such as butter, nonfat dry milk, or American, Italian, or semi-soft cheeses (Muenster and the like), and evaporated milk. In this study this concept is widened to include also the producers of soft dairy products.

MANUFACTURING: Is here defined as the conversion of grade A or B milk to dairy products other than those defined as class I use.

MANUFACTURING MILK PRICE: is the price paid by manufacturers.

MANUFACTURING PLANTS: These plants process storable manufactured dairy products.

NMPF: National Milk Producers Federation.

POOLING PRICE: Mechanism which insures that grade A milk producers receive the blend price. The dairy cooperative associations marketing their members' milk under Federal orders are entitled to blend the net proceeds from sales of milk.

PRICE SUPPORT: The government stands ready to purchase butter, nonfat dry milk, and cheese at prices sufficient to support the manufacturing milk price at the level established under the support program.

PROCESSING: Is, here, the conversion of grade A milk to fluid dairy products.

PROCESSORS: Is, here referred to a concern that bottles, or packages grade A milk for drinking purposes.

SOFT MANUFACTURED PRODUCTS: Yogurt, ice cream, and cottage cheese.

VERTICAL COORDINATION: When all transactions in a subsector are taken together, involving hundreds of different kinds of firms at different stages in the subsector, their synchronization is called vertical coordination. Vertical coordination is a process by which the various functions in a subsector are brought into harmony with respect to a single managerial control.

APPENDIX C
VARIANCE-COVARIANCE MATRICES FOR ESTIMATED COEFFICIENTS

Table C-1. Derived Demand for Fluid Milk: Variance-Covariance Matrix of the Estimated Coefficients

	Intercept	R1 log(PF)	R2 log(PF)	R3 log(PF)	R4 log(PF)	R5 log(PF)	R6 log(PF)
Intercept	2.13204423	-0.00735138	0.00020581	0.03061322	0.00954136	0.00099307	0.00411604
R1 log(PF)	-0.00735139	0.10626459	0.10588966	0.10478729	0.10666979	0.10980301	0.11136069
R2 log(PF)	0.00020581	0.10588966	0.10672843	0.10515573	0.10719785	0.11019449	0.11181727
R3 log(PF)	0.03061322	0.10478728	0.10515573	0.10500857	0.10609835	0.10881398	0.11048298
R4 log(PF)	0.00954136	0.10666979	0.10719785	0.10609935	0.10918139	0.11099879	0.11263753
R5 log(PF)	0.00099307	0.10980301	0.11019449	0.10801388	0.11099873	0.11459353	0.11595424
R6 log(PF)	0.00411604	0.11136069	0.11181727	0.11048298	0.11261753	0.11595424	0.11812673
R7 log(PF)	0.01074374	0.11059953	0.11117532	0.11000348	0.11202509	0.11515787	0.11684461
R8 log(PF)	0.00473290	0.10117610	0.10872420	0.10749679	0.10952917	0.11260943	0.11425265
R9 log(PF)	-0.02732047	0.10199797	0.10297932	0.10051940	0.10338205	0.10664162	0.10814604
log(E)	0.01364629	-0.01215324	-0.01071577	-0.01189231	-0.01122157	-0.01168214	-0.01166472
log(W)	0.05301501	-0.00092735	-0.00122549	0.00142995	-0.00089786	-0.00288895	-0.00230535
log(PO)	-0.47250459	-0.03751579	-0.04002099	-0.04633311	-0.04234085	-0.04097226	-0.04244295
log(Y)	-0.00272664	-0.00024969	-0.00009554	-0.00018901	-0.00010689	-0.00015332	-0.00015035
S1	-0.00618404	0.00084968	0.00075974	0.00076293	0.00076353	0.00078961	0.00079264
S2	-0.00611879	0.00147376	0.00141991	0.00137658	0.00141766	0.00147049	0.00147535
S3	-0.00521957	0.00113500	0.00110127	0.00104599	0.00109398	0.00114301	0.00114328

	R7 log(PF)	R8 log(PF)	R9 log(PF)	log(E)	log(W)	log(PO)	log(Y)
Intercept	0.01074374	0.00473290	-0.02732047	0.01364629	0.05301501	-0.47250459	-0.00272664
R1 log(PF)	0.11059953	0.10117610	0.10199797	-0.01215324	-0.00092735	-0.03751579	-0.00024969
R2 log(PF)	0.11117532	0.10872420	0.10297932	-0.01071577	-0.00122549	-0.04002099	-0.00009554
R3 log(PF)	0.11000348	0.10749679	0.10051940	-0.01189231	0.00142995	-0.04633311	-0.00018901
R4 log(PF)	0.11202509	0.10952917	0.10338205	-0.01122157	-0.00089786	-0.04234095	-0.00010689
R5 log(PF)	0.11515787	0.11260943	0.10664162	-0.01168214	-0.00288895	-0.04097226	-0.00015332
R6 log(PF)	0.11684461	0.11425265	0.10814604	-0.01166472	-0.00230535	-0.04244295	-0.00015035
R7 log(PF)	0.11649263	0.11761236	0.10725278	-0.01166836	-0.00136090	-0.04407395	-0.00008731
R8 log(PF)	0.11361236	0.11132494	0.10496114	-0.01143373	-0.00143505	-0.04183980	-0.00007625
R9 log(PF)	0.10725278	0.10496114	0.10272604	-0.00676844	-0.00516867	-0.03228085	-0.00007633
log(E)	-0.01166836	-0.01143373	-0.00676844	0.01057051	-0.00186995	0.00039991	-0.00002653
log(W)	-0.00136090	-0.00143505	-0.00516867	-0.00186995	0.01709015	-0.01410166	-0.00028716
log(PO)	-0.04407385	-0.04183980	-0.03228085	0.00039981	-0.01410166	0.12153929	0.00031205
log(Y)	-0.00008731	-0.00007625	-0.00007633	-0.00002653	-0.00028716	0.00031205	0.00011708
S1	0.00078543	0.00078324	0.00059193	-0.00057635	0.00018282	0.00098801	.00000407052
S2	0.00146757	0.00145036	0.00131699	-0.00045030	0.00003298	0.00072535	0.0000065497
S3	0.00113381	0.00112170	0.00106269	-0.00028888	-0.00005647	0.00065675	.00000535554

	S1	S2	S3
Intercept	-0.00618404	-0.00611879	-0.00521957
R1 log(PF)	0.00084968	0.00147376	0.00113590
R2 log(PF)	0.00075974	0.00141991	0.00110127
R3 log(PF)	0.00076293	0.00137658	0.00104599
R4 log(PF)	0.00076353	0.00141766	0.00109398
R5 log(PF)	0.00078961	0.00147049	0.00114301
R6 log(PF)	0.00079264	0.00147535	0.00114328
R7 log(PF)	0.00078543	0.00146757	0.00113381
R8 log(PF)	0.00078324	0.00145036	0.00112170
R9 log(PF)	0.00059193	0.00131699	0.00106269
log(E)	-0.00057635	-0.00045030	-0.00028800
log(W)	0.00018282	0.00003298	-0.00005647
log(PO)	0.00098801	0.00072535	0.00065675
log(Y)	.00000407052	0.0000065497	.00000535554
S1	0.00083192	0.00043356	0.00042124
S2	0.00043356	0.00082338	0.00042492
S3	0.00042124	0.00042492	0.00000457

Table C-2. Derived Demand for Commercial Manufacturing Milk: Variance-Covariance Matrix of the Estimated Coefficients

	Intercept	R1 log(PM)	R2 log(PM)	R4 log(PM)	R5 log(PM)	R6 log(PM)	R7 log(PM)
Intercept	21.02132743	0.90863028	0.98439529	1.10317956	1.01548441	1.04945822	1.11753722
R1 log(PM)	0.90863028	1.00931278	1.07488130	1.09373507	1.09787852	1.09858573	1.09931207
R2 log(PM)	0.98439529	1.07488130	1.07470499	1.08987352	1.09220650	1.09362057	1.09570936
R4 log(PM)	1.10317956	1.09373507	1.08987352	1.11120502	1.11128981	1.11276452	1.11528777
R5 log(PM)	1.01548441	1.09787852	1.09220650	1.11128981	1.11908120	1.11696818	1.11771193
R6 log(PM)	1.04945822	1.09858573	1.09362057	1.11276452	1.11696818	1.12330035	1.11903585
R7 log(PM)	1.11753722	1.09931207	1.09570936	1.11528777	1.11771193	1.11903585	1.12772106
R8 log(PM)	1.04661804	1.08997977	1.08622997	1.10531815	1.10791777	1.10915726	1.11146442
R9 log(PM)	0.64225811	1.01145389	1.01385228	1.02722554	1.03326848	1.03401205	1.03301329
log(WM)	0.46924162	-0.01220421	-0.01486685	-0.01172173	-0.03124651	-0.02495564	-0.01606019
log(EM)	0.05943806	-0.07865250	-0.06163871	-0.06768832	-0.06985564	-0.06766562	-0.06858686
log(POM)	-4.97633085	-0.55083193	-0.57304374	-0.60496394	-0.58036469	-0.59011121	-0.60978604
log(Y)	-0.02816497	-0.00387950	-0.00233883	-0.00248245	-0.00289698	-0.00287540	-0.00226152
S1	-0.02788872	0.02851857	0.02740102	0.02789032	0.02800615	0.02794171	0.02798236
S2	-0.02959395	0.02589472	0.02515006	0.02547920	0.02567092	0.02552255	0.02559666
S3	-0.03250084	0.01656206	0.01609210	0.01621711	0.01643369	0.01628184	0.01629959

	R8 log(PM)	R9 log(PM)	log(WM)	log(EM)	log(POM)	log(Y)	S1
Intercept	1.04661804	0.64225811	0.46924162	0.05943806	-4.97633085	-0.02816497	-0.02788872
R1 log(PM)	1.08997977	1.01145389	-0.01220421	-0.07865250	-0.55083193	-0.00387950	0.02851857
R2 log(PM)	1.08622997	1.01385228	-0.01486685	-0.06163871	-0.57304374	-0.00233883	0.02740102
R4 log(PM)	1.10531815	1.02722554	-0.01172173	-0.06760832	-0.60496394	-0.00248245	0.02789032
R5 log(PM)	1.10791777	1.03326848	-0.03124651	-0.06985564	-0.58036469	-0.00289698	0.02800615
R6 log(PM)	1.10915726	1.03401205	-0.02495564	-0.06766562	-0.59011121	-0.00287540	0.02794171
R7 log(PM)	1.11146442	1.03301329	-0.01606019	-0.06858686	-0.60978604	-0.00226152	0.02798236
R8 log(PM)	1.10423671	1.02494240	-0.01695571	-0.06018302	-0.59112980	-0.00214842	0.02788846
R9 log(PM)	1.02494240	0.99035914	-0.05256355	-0.01880663	-0.47520864	-0.00212227	0.02428173
log(WM)	-0.01695571	-0.05256355	0.16037652	-0.01501072	-0.12417049	-0.00259478	0.00137061
log(EM)	-0.06818302	-0.01880663	-0.01501072	0.09872872	0.00089558	-0.00043158	-0.00651504
log(POM)	-0.59112980	-0.47520864	-0.12417049	0.00089558	1.30723532	0.00412980	-0.00377619
log(Y)	-0.00214842	-0.00212227	-0.00259478	-0.00043158	0.00412980	0.00104918	-0.00001306
S1	0.02780946	0.02428173	0.00137061	-0.00651504	-0.00377619	-0.00001306	0.00967339
S2	0.02552306	0.02309461	0.00010135	-0.00453516	-0.00267919	0.00001984	0.00471286
S3	0.01629002	0.01513514	-0.00058322	-0.00266572	0.00102877	0.00002843	0.00439380

	S2	S3
Intercept	-0.02959395	-0.03250084
R1 log(PM)	0.02589472	0.01656206
R2 log(PM)	0.02515006	0.01609210
R4 log(PM)	0.02547920	0.01621711
R5 log(PM)	0.02567092	0.01643369
R6 log(PM)	0.02552255	0.01628184
R7 log(PM)	0.02559666	0.01629959
R8 log(PM)	0.02552306	0.01629002
R9 log(PM)	0.02309461	0.01513514
log(WM)	0.00010135	-0.00058322
log(EM)	-0.00453516	-0.00266572
log(POM)	-0.00267919	0.00102877
log(Y)	0.00001984	0.00002843
S1	0.00471286	0.00439380
S2	0.00834068	0.00432887
S3	0.00432887	0.00790055

	Intercept	PAt-1	PAt-2	PAt-3	PAt-4	PAt-13	PAt-14
Intercept	11751.23354641	-283.11509924	-525.36633363	-85.23039453	-781.22312426	-259.12290583	119.70615143
PAt-1	-283.11509924	434.23915875	-222.09469238	139.57588289	-69.24094473	19.90702317	36.43515732
PAt-2	-525.36633363	-222.09469238	409.86291209	-240.23138837	113.51879034	6.70086172	-17.90794625
PAt-3	-85.23039453	139.57588289	-240.23138837	378.05926254	-160.31884193	-58.77440678	12.74530733
PAt-4	-781.22312426	-69.24094473	113.51879034	-160.31884193	269.33434470	2.04861726	-51.60043758
PAt-13	-259.12290583	19.90702317	6.70086172	-58.77440678	2.04861726	152.50586010	-54.80031279
PAt-14	119.70615143	36.43515732	-17.90794625	12.74530733	-51.60043758	-54.80031279	159.97107615
PAt-15	74.15914530	-44.03004083	26.24310565	-9.70479054	-13.33108726	19.38566884	-60.16107622
PAt-16	206.15618455	-55.47669837	-60.11822837	13.55301650	-20.80630376	-32.68667215	24.46481130
S1	-92.50608685	-157.91237168	-5.32317232	64.60073427	22.97362552	-83.14775705	-16.23505726
S2	-301.68007828	-104.51539270	-115.52262173	33.77780708	98.27072983	-22.44505270	-107.92868457
S3	-344.05036767	-29.30723996	-32.96072921	-92.56810717	112.46440719	27.32893077	-54.33734280
PBt-1	-50.64304217	-1.62976550	1.79716951	-0.41298737	1.88814025	2.34420380	0.98438954
C	-0.03442419	-0.01281317	-0.00752636	-0.00982756	-0.01974800	0.01828429	0.01625543
PDF	-1.34117118	0.40341104	-1.25530071	0.49781311	0.28714306	-0.19002807	-0.07555555
PMC	-2.37046042	0.34542135	0.28184247	0.19579652	0.54251056	-0.29597113	-0.33840130
R1 PAt	-346.15598729	-207.02237945	79.47450182	-81.39164521	13.34295370	21.28782766	-33.67388128
R2 PAt	-345.11367502	-203.15526799	82.02416374	-79.85298979	18.12136097	17.28026379	-37.56902090
R3 PAt	-209.13077161	-208.74041143	74.33321959	-80.70524152	9.50224703	13.88465011	-36.47944284
R4 PAt	-307.78962614	-205.65500687	78.58529584	-80.46881833	14.47853655	17.64911794	-36.02615458
R5 PAt	-379.41484944	-205.70955120	82.47177030	-82.39613260	14.54887231	23.52439444	-33.00962130
R6 PAt	-491.46867521	-201.81348616	86.22277223	-81.00836378	22.23069099	26.20302761	-33.49044717
R7 PAt	-429.29460096	-203.83561795	82.84721429	-81.54717348	17.52797641	24.36365450	-33.18003893
R8 PAt	-383.51199563	-207.84435859	60.04555652	-82.13355030	14.21485995	24.03758653	-32.37397367
R9 PAt	-432.[illegible]	-206.91598947	82.23911148	-82.40397645	15.83419140	26.27993373	-31.38909089

	PAt-15	PAt-16	S1	S2	S3	PBt-1	C
Intercept	74.15914530	206.15618455	-92.50608685	-301.68007829	-344.05036767	-50.64304217	-0.03442419
PAt-1	-44.03004083	-55.47669837	-157.91237168	-104.51539270	-29.30723996	-1.62976550	-0.01281317
PAt-2	26.24310565	-60.11822837	-5.32317232	-115.52262173	-33.96072921	1.79716951	-0.00752636
PAt-3	-9.70479054	13.55301650	64.60073427	33.77780708	-92.56810717	-0.41298737	-0.00982756
PAt-4	-13.33108726	-20.80630376	22.97362552	98.27072983	112.46440719	1.88814025	-0.01974800
PAt-13	19.38566884	-32.68667215	-83.14775705	-22.44505270	27.32893077	2.34420380	0.01828429
PAt-14	-60.16107622	24.46481130	-16.23505726	-107.92868457	-54.33734289	0.98438954	0.01625543
PAt-15	160.11948256	-56.71185629	27.52995255	24.02503404	-56.25820523	0.50496939	0.01513853
PAt-16	-56.71185629	149.77229955	49.18050489	86.05697912	77.58402222	0.26918748	0.02327059
S1	27.52995255	49.18050489	242.03237833	188.53792209	67.19444130	-0.65789681	-0.00149250
S2	24.02503404	86.05697912	188.53792209	383.02563661	198.32407042	-0.14376019	0.00204588
S3	-56.25820523	77.58402222	67.19444130	198.32407042	254.50881805	0.46696847	0.00260308
PBt-1	0.50496939	0.26918748	-0.65789681	-0.14376019	0.46696847	5.17371753	-0.00229811
C	0.01513853	0.02327059	-0.00149250	0.00204588	0.00260308	-0.00229811	0.00024158
PDF	0.19379842	-0.70929836	-0.76201330	-1.09949537	-0.95163547	0.10395580	-0.00083164
PMC	-0.30995135	-0.48159749	0.03842780	0.01589748	0.02124550	-0.01681601	-0.00041133
R1 PAt	-13.22553948	40.88558284	100.65073117	141.61036316	98.11522624	2.94069230	0.01687325
R2 PAt	-16.42698498	36.59739899	101.83613670	142.73180332	98.83933348	-0.93632760	0.01890560
R3 PAt	-15.52787293	39.35910554	101.58432094	140.52967747	95.47440741	1.41009044	0.01776498
R4 PAt	-14.98416598	38.46627242	100.97748713	141.08258278	97.17056537	0.70828841	0.01948861
R5 PAt	-12.69879615	42.82500071	101.90161249	144.24807924	100.87842425	-0.58613929	0.02114357
R6 PAt	-12.85260791	40.19959691	100.92292705	144.26033575	101.97635908	-0.13795886	0.00654695
R7 PAt	-12.62691719	41.44062825	100.89750169	143.31110746	100.53054928	-0.62923765	0.02641050
R8 PAt	-11.75539479	32.19372067	100.07117157	141.68516050	98.77245195	2.29749466	0.02692713
R9 PAt	-10.[illegible]	43.92930312	100.88915219	143.81465922	100.98349456	0.71117277	0.02126057

	PDF	PMC	R1 PAt	R2 PAt	R3 PAt	R4 PAt	R5 PAt
Intercept	-1.34117118	-2.37046042	-346.15598729	-345.11367502	-209.13077161	-307.78962614	-379.41484944
PAt-1	0.40141104	0.34542135	-207.02237945	-203.15526799	-208.74041143	-205.65500687	-205.70955120
PAt-2	-1.25530071	0.28184247	79.47450182	82.02416374	74.33321959	78.58529584	82.47177030
PAt-3	0.49781311	0.19579652	-81.39164521	-79.85298979	-80.70524152	-80.46881833	-82.39613260
PAt-4	0.28714306	0.54251056	13.34295370	18.12136097	9.50224703	14.47853655	14.54887231
PAt-13	-0.19002807	-0.29597113	21.28782766	17.28026379	13.88465011	17.64911794	23.52439444
PAt-14	-0.07555555	-0.33840130	-33.67388128	-37.56902090	-36.47944284	-36.02615458	-33.00962120
PAt-15	0.19379842	-0.30995135	-13.22553948	-16.42698498	-15.52787393	-14.98416598	-12.69879615
PAt-16	-0.70929836	-0.43159739	40.88558284	36.59739899	39.35910554	38.46627242	42.82500071
S1	-0.76201330	0.03842780	100.65073117	101.83613670	101.58432094	100.97748713	101.90161249
S2	-1.09949537	0.01589748	141.61036316	142.73180332	140.52967747	141.08258278	144.24807924
S3	-0.95163547	0.02124550	98.11522624	98.83933348	95.47440741	97.17066637	100.87842425
PBt-1	0.10395580	-0.01681601	2.94069230	-0.93632760	1.41009044	0.70828841	-0.58613929
C	-0.00083164	-0.00041133	0.01607335	0.01890560	0.01776498	0.01948861	0.02114357
PDF	0.36811515	0.00596785	-4.05405109	-4.17728331	-3.89795000	-3.89728050	-4.68074721
PMC	0.00596785	0.00838306	-0.26199604	-0.17060934	-0.20761770	-0.20873715	-0.28427762

Table C-3. Continued

	PDF	PMC	R1 PAt	R2 PAt	R3 PAt	R4 PAt	R5 PAt
R1 PAt	-4.05405169	-0.26199684	300.54586921	296.08397112	291.56801307	293.12702008	304.85644237
R2 PAt	-4.17728331	-0.17860934	296.08397112	300.77203042	290.36621620	292.54655382	304.80804717
R3 PAt	-3.89795000	-0.20761770	291.56801307	290.36621620	291.37682726	287.48857147	297.29255532
R4 PAt	-3.89728050	-0.20873715	293.12702008	292.54655382	287.48857147	291.82680207	300.12136845
R5 PAt	-4.68074721	-0.28427762	304.85644237	304.80804717	297.29255532	300.12136845	318.81931393
R6 PAt	-4.26087661	-0.25788976	302.08535265	301.73562104	293.01620778	296.89555528	311.95324011
R7 PAt	-4.27277392	-0.27009113	300.37375310	300.50604270	292.67860572	295.92919531	310.06250379
R8 PAt	-3.97739309	-0.29105330	298.82292391	296.56622218	291.18764021	293.39977583	305.73149961
R9 PAt	-4.21610267	-0.31734457	303.18697909	301.85443395	294.56206957	297.77508981	312.15469745

	R6 PAt	R7 PAt	R8 PAt	R9 PAt
Intercept	-401.46867521	-420.99460096	-383.51395569	-432.90896679
PAt-1	-201.81348616	-203.83561795	-206.84435859	-206.01608547
PAt-2	86.23277223	82.84721499	80.04555652	82.22011148
PAt-3	-81.00836398	-81.54717348	-82.13255030	-82.40397645
PAt-4	22.33069099	17.52397641	14.21485995	15.83419140
PAt-13	26.20302761	24.36365450	24.02759653	26.27993373
PAt-14	-33.49044717	-33.18003893	-32.37397367	-31.38909089
PAt-15	-12.85260791	-12.62691719	-11.75539970	-10.95468841
PAt-16	40.19859691	41.44062825	42.19872067	43.92990312
S1	100.92292705	100.89750169	100.07117157	100.88935219
S2	144.26033575	143.31110746	141.68516050	143.81465922
S3	101.97635908	100.53064928	98.77245195	100.90348456
PBt-1	-0.13795886	-0.62023765	2.29749466	0.71117277
C	0.00654695	0.02641050	0.07692713	0.02126057
PDF	-4.26087661	-4.27277392	-3.97739309	-4.21610267
PMC	-0.25788976	-0.27009113	-0.29105330	-0.31734457
R1 PAt	302.08535265	300.37375310	298.82292391	303.18697909
R2 PAt	301.73562104	300.50604270	296.56622218	301.85443395
R3 PAt	293.01620778	292.67860572	291.18764021	294.56206957
R4 PAt	296.89555528	295.92919531	293.39977583	297.77508981
R5 PAt	311.95324011	310.06250379	305.73149961	312.15469745
R6 PAt	317.32866224	307.61426377	302.97104778	310.29752815
R7 PAt	307.61426377	309.24615752	301.73674791	307.94173097
R8 PAt	302.97104778	301.73674791	304.79798024	304.37969502
R9 PAt	310.29752815	307.94173097	304.37969502	314.84846838

	Intercept	PB (Simul.)	PDF	FW	PC	PA-1	PA-2
Intercept	5825.29574521	-1858.62433765	17.57372247	697.56560533	21.97591302	134.85561011	-519.92732473
PB (Simul.)	-1858.62433765	2353.62850767	-37.60565437	-1114.06267991	-89.61840953	-385.78214966	323.77646226
PDF	17.57372247	-37.60565437	0.76109122	16.43256212	1.64169874	6.22941887	-5.09178480
FW	697.56560533	-1114.06267991	16.43256712	985.23745645	43.65478917	147.10032750	-138.65730692
PC	21.97591302	-89.61840953	1.64169874	43.65478917	4.30395528	15.62947155	-10.29850218
PAt-1	134.85561011	-385.78214966	6.22941887	147.10032750	15.62947155	135.08595456	-77.55654481
PAt-2	-519.92732473	323.77646226	-5.09175480	-136.86730692	-10.29850218	-77.55654481	107.61970002
S1	-570.02641913	846.73792153	-11.67968025	-387.22989898	-33.36548731	-159.94025859	118.16241348
S2	-475.02629466	805.73350949	-13.10975745	-365.64242927	-32.49845706	-131.10121359	83.70906377
S3	-381.86720754	515.26687415	-8.26727406	-222.37054241	-20.08691450	-72.74147091	53.94188342
E	1371.75444082	-1840.41539039	28.75070944	721.19584736	71.36628753	278.63221987	-248.02603268
ZSB11	-656.96599958	1148.55501677	-19.22755591	-505.76366442	-46.59186124	-215.83863771	134.42058745
ZSB12	-151.21911758	344.75458539	-5.40411499	-149.43468208	-14.50692530	-73.14774369	30.61025108
ZSB13	-468.37378422	497.51270819	-6.37183789	-429.06511441	-10.37889596	-59.03587131	64.21699141
ZSB14	940.45901536	-1355.11529319	20.89280541	476.98074832	52.06982496	216.90911648	-179.23579171
ZSB15	-281.98371938	469.86210860	-8.50679508	-238.70496046	-20.18956514	-67.40995675	59.90745397
ZSB16	-702.88157527	1087.85093942	-10.89685088	-557.26212086	-44.16040024	-188.92233146	138.89419622
ZSB17	-106.75997896	120.07236989	-2.52907023	-68.58850037	-5.83148181	-11.75379250	17.13352812
ZSB18	-310.22097065	485.21632019	-7.83876298	-288.62194922	-19.91522852	-77.74493172	57.69811731
ZSB19	-138.85314859	137.29179826	-3.03464301	-66.65522390	-5.60502587	-36.50365712	18.22163022
ZSB20	-1021.03078224	1485.20215581	-25.10387551	-726.53205732	-59.76178794	-237.00859311	198.35512898
ZSB21	148.45852755	-397.20051199	6.67138111	162.88892878	15.90011376	72.03620144	-47.33676749
ZSB22	-248.39201508	412.37837003	-6.65126073	-185.70940806	-16.64619614	-82.10219030	43.94734711
ZSB23	255.02268222	-347.20262653	5.71554520	121.60156517	12.97448141	61.57655459	-52.91900253
ZSB24	321.35069742	-194.86021466	2.31728135	128.05281515	5.49377222	3.81797188	-44.07564085
ZSB25	126.88979036	-385.06041973	6.26907583	38.55106716	15.72834256	71.01258807	-44.374[illegible]9048
ZSB26	-513.17230155	818.40237360	-14.13262935	-410.08168827	-33.51377486	-134.95939877	104.40008101
ZSB27	83.50857094	5.39528011	-8.07732153	-30.00346092	-1.22223614	-17.62065878	-12.55340856
ZSB28	1807.65974278	-2357.08137788	37.18214307	917.48645603	90.29078878	367.29306354	-326.96316640
ZSB29	270.75446772	-110.67150423	1.07258946	72.62628202	2.37326001	4.75575941	-32.86396599
ZSB30	477.23398103	-704.00126503	10.24448194	370.55224470	26.31271262	106.35350622	-91.77062081
ZSB31	496.83253062	-676.68471197	9.96505225	280.75768506	26.03031088	86.24215570	-95.59371208
ZSB32	340.96570393	-651.09627340	11.27456110	262.99062841	26.38393290	111.27927425	-86.00425425
ZSB33	-308.35914528	530.40685985	-9.54616690	-190.72912649	-22.18038859	-99.24432277	63.10081104
ZSB34	502.50258015	-741.73287269	11.00076613	429.19241180	27.70586504	117.62320794	-96.47325458

	S1	S2	S3	E	ZSB11	ZSB12	ZSB13
Intercept	-570.02641913	-475.02629466	-381.86720754	1371.75444082	-656.96599958	-151.21911758	-468.37378422
PB (Simul.)	846.73792151	805.73150949	515.26687415	-1840.41539039	1148.55501677	344.75458539	497.51270819
PDF	-13.67968025	-11.10975745	-8.26727406	28.75070944	-19.22755591	-5.40411499	-6.37183789
FW	-387.22989898	-365.64242927	-222.37054241	721.19584736	-505.76366442	-149.43468208	-429.06511441
PC	-33.36548731	-32.49845706	-20.08691450	71.36628753	-46.59186124	-14.50692530	-18.37889596
PAt-1	-159.94025859	-131.10121359	-72.74147091	278.63221987	-215.83863771	-73.14774369	-59.03587131
PAt-2	118.16241348	83.70906377	53.94188342	-248.02603268	134.42058745	30.61825108	64.21699141
S1	333.37598371	303.72600002	194.31807415	-661.67657309	425.71068581	131.81028566	178.66878083
S2	303.72600002	311.84049597	194.97441853	-638.28034000	410.89912334	129.41513958	161.06541967
S3	194.31807415	194.97441853	141.09122883	-418.67102352	256.29465268	78.85376348	100.70501750
E	-661.67657309	-638.28034000	-418.67102352	1644.49657822	-899.24418063	-280.27735517	-352.33098297
ZSB11	425.71068581	410.89912334	256.29465268	-899.24418063	729.47281326	255.14839420	283.94410956
ZSB12	131.81028566	129.41513958	78.85376348	-280.27735517	255.14839420	198.60902128	132.66655204
ZSB13	170.66878083	161.06541967	100.70501750	-352.33098297	283.94410956	132.66655204	329.86576197
ZSB14	-491.29379242	-474.88966076	-311.34619450	1225.88843814	-605.24867084	-146.57027604	-170.91559835
ZSB15	168.54093325	162.93521690	104.04691906	-392.36425685	298.89489745	135.82459375	171.09531306
ZSB16	396.05998085	378.43067707	235.99782990	-802.27276211	613.93979111	230.15560642	299.57553975
ZSB17	42.00320060	40.70833575	26.54085221	-104.98011829	123.80142342	81.85572826	95.97032432
ZSB18	175.45689476	168.63589761	104.99197753	-373.70690491	306.35719074	141.27849841	193.59957671
ZSB19	52.71277571	48.70943381	27.60632584	-54.66599006	143.58641054	87.20222439	84.31724109
ZSB20	535.41318634	512.75632300	326.19858219	-1175.76992181	799.26097779	286.16418091	385.16947799
ZSB21	-146.51894763	-141.71377345	-89.47404610	323.09777790	-138.53263441	1.92260915	-4.77623290
ZSB22	154.55996854	149.77765505	92.33959940	-322.72660651	284.62646581	138.15187954	147.11018335
ZSB23	-123.47758034	-117.58528012	-78.19389546	301.17156018	-100.06033404	18.09557427	8.74747206
ZSB24	-50.99222235	-52.73295619	-39.74432483	168.20537048	2.44205274	54.29409348	-0.63986797
ZSB25	-145.26138297	-144.10432552	-95.55975000	404.09001540	-140.82190291	-4.14712983	38.48726147
ZSB26	296.72857490	204.70356238	179.33124964	-634.84630386	475.69594668	169.71753010	242.59072522
ZSB27	8.19881034	9.36556690	0.63198153	22.77606555	84.08212221	77.74070038	74.37348579
ZSB28	-847.68861286	-813.49784689	-532.32507803	2045.64169735	-1084.35714198	-286.41871841	-372.56309462
ZSB29	-39.14890735	-33.61723277	-26.46134901	114.40476465	26.21640819	58.79146382	24.81512294
ZSB30	-251.16131364	-240.49766249	-154.63304319	578.84095516	-270.15242106	-38.75240722	-107.77235461
ZSB31	-238.62162732	-230.39927700	-154.48552071	639.04185456	-250.29344808	-31.95029705	-78.95578422
ZSB32	-237.64359003	-228.24229356	-145.73519880	530.56670947	-262.46953769	-33.00587517	-48.15395124
ZSB33	197.41155724	191.52780562	120.75768631	-436.41485757	348.60633452	154.09411806	147.02591243
ZSB34	-265.08763026	-252.20649079	-159.34424179	562.07638678	-209.11653217	-42.64406842	-126.92230808

	ZSB14	ZSB15	ZSB16	ZSB17	ZSB18	ZSB19	ZSB20
Intercept	940.45901536	-281.98371930	-702.88157527	-108.75997896	-310.22097065	-130.85314859	-1021.03078224
PB (Simul.)	-1355.11529319	469.86218860	1087.85893942	120.87236989	405.21632019	137.29179826	1485.20215581
PDF	20.89280541	-0.50679508	-18.89685088	-2.52907023	-7.83876298	-3.03464301	-25.10307551
FW	476.98074832	-230.70496046	-557.26212086	-68.58850037	-288.62194922	-66.65523390	-726.53205732
PC	52.06982496	-20.18956514	-44.16040024	-5.83148181	-19.91522852	-5.60502587	-59.76178794
PAt-1	216.90911640	-67.40995675	-108.92233146	-11.75379250	-77.74493172	-36.50365712	-237.00059311
PAt-2	-179.23579171	59.90745397	138.89419622	17.13352812	57.69811731	18.22183022	196.35612858
S1	-491.29379242	168.54093325	396.05998005	42.00320060	175.45689476	52.71277571	535.41318634
S2	-474.88966076	162.93521690	378.43867787	40.70833575	168.63589761	48.70943383	512.75632300
S3	-311.34619450	104.04691906	235.95782990	26.54085221	104.99197753	27.60632584	326.19858219
E	1225.88843814	-392.36425685	-802.27276211	-104.98011829	-373.70690491	-54.66599006	-1175.76992181
ZSB11	-605.24867084	298.89409745	613.93979111	123.80142342	306.35719074	143.58641054	799.26097779
ZSB12	-146.57027604	135.82459375	230.15560642	81.85572026	141.27849841	87.20222499	286.16418091
ZSB13	-170.91559635	171.09531306	299.57553975	95.97032432	193.59957671	84.31724109	305.16947799
ZSB14	1056.74308178	-216.10834401	-518.11040002	-5.91867900	-201.98251580	26.12680774	-791.95751131
ZSB15	-216.10034401	244.29289480	290.74639856	100.05812057	171.46917810	88.18271445	381.90403189
ZSB16	-518.11048002	290.74639856	665.06694496	126.11140359	299.50835762	147.84069055	767.02587056
ZSB17	-5.91867900	100.05812057	126.11140359	145.16015321	95.27394814	70.87495895	153.01768993
ZSB18	-201.98251580	171.46917810	299.50835762	95.27394814	244.80872878	92.81091499	382.69778046
ZSB19	26.12680774	88.18271445	147.84069055	70.87495895	92.81091499	160.89451522	151.67572074
ZSB20	-791.95751131	381.90403189	767.02587056	153.01768993	382.69778046	151.67572074	1092.70927286
ZSB21	309.36145051	-15.34730515	-119.31039982	46.09288601	-15.13551054	43.12265877	-187.51843539
ZSB22	-176.09475165	148.61686412	263.15543216	85.58130773	154.13225927	93.96572442	328.29168287
ZSB23	291.31372944	-5.30535123	-85.54522392	47.13071690	0.34074129	52.13281244	-153.18610966
ZSB24	181.27919928	25.78084425	-6.96920990	52.89960963	26.39998387	69.46300087	-53.59541152
ZSB25	382.86840305	-16.89833688	-90.78768077	46.31751271	-2.08369633	61.48331235	-179.28056398
ZSB26	-396.02529552	241.05937964	459.75954302	114.35218045	242.86098150	118.34526612	597.74419036
ZSB27	81.95868539	65.18729493	81.64734125	63.82896242	73.82728886	75.33529652	70.73903630
ZSB28	1592.88770826	-422.52289800	-971.14407852	-62.10197094	-404.19348345	-23.09111352	-1428.25636832
ZSB29	147.74983095	44.91843290	23.65489562	60.68714651	43.42664901	69.49347643	-6.65052897
ZSB30	490.25414584	-78.00517762	-248.26127230	29.23639148	-85.80179533	40.59590681	-378.88559550
ZSB31	538.87488275	-83.20317034	-215.30235304	24.39039684	-73.51517383	61.84752580	-368.02902311
ZSB32	461.26616241	-69.71390105	-237.75392749	30.37078634	-65.36324415	27.93434701	-351.91594876
ZSB33	-262.08012243	178.73292134	318.94571700	95.60193128	173.58177085	101.41548514	409.89492282
ZSB34	473.82524900	-81.06922566	-277.73375076	29.15940538	-96.42386210	26.91882534	-400.88050846

	ZSB21	ZSB22	ZSB23	ZSB24	ZSB25	ZSB26	ZSB27
Intercept	148.45852755	-246.39201588	255.02268222	321.35069742	126.88979036	-533.17230155	83.50857094
PB (Simul.)	-397.20851199	412.37837003	-347.20262653	-194.86021466	-385.06041973	818.40237360	5.39528011
PDF	6.67138111	-6.65126073	5.71554520	2.31728135	6.26907583	-14.13262935	-0.07732153
FW	162.88892878	-185.70940806	121.60156517	128.85281515	30.55106716	-410.08168827	-30.00346092
PC	15.90011376	-16.64619614	12.97448141	5.49377222	15.72834256	-33.51377486	-1.22223614
PAt-1	72.03620144	-82.10219030	51.57655459	3.01797188	71.01258807	-134.95939877	-17.62065878
PAt-2	-47.33676749	43.94734711	-52.91908253	-44.07564088	-44.37419048	104.40008101	-12.55340856
S1	-146.51894763	154.55996854	-123.47758034	-58.99222235	-145.26138297	296.72857490	8.19881034
S2	-141.71377345	149.77765505	-117.58528012	-52.73295619	-144.10433352	284.70356238	9.36556690
S3	-89.47404610	92.33959940	-78.19309546	-39.74432483	-95.55975000	179.33124964	0.63198253
E	323.89777790	-322.72660651	301.17156018	168.28537048	404.09001540	-634.64630386	22.77606555
ZSB11	-138.53263443	284.62648581	-100.06033404	2.44205224	-140.82190291	475.69594668	84.88212221
ZSB12	1.92268915	138.19187954	18.09557427	54.29409348	-4.14712983	189.71753810	77.74070038
ZSB13	-4.77623290	147.11018335	8.74747206	-0.63986797	38.48726147	242.59072522	74.37348579
ZSB14	309.36145051	-176.09475165	291.31372944	181.27919928	382.86840385	-396.02529552	81.95868539
ZSB15	-15.34730515	148.61686412	-5.30535123	25.78084425	-16.89833688	241.05937964	65.18729493
ZSB16	-119.31039982	263.15543216	-85.54522392	-6.96920990	-90.78768077	459.75954302	81.64734125
ZSB17	46.09288601	85.58130773	47.13071690	52.89960963	46.31751271	114.35218045	63.82896242
ZSB18	-15.13551054	154.13225927	0.34074129	26.39998387	-2.08369633	242.86098150	73.82728886
ZSB19	43.12265877	93.96572442	52.13281244	69.46300087	61.48331235	118.34526612	75.33529652
ZSB20	-187.51843539	328.29168287	-153.18610966	-53.59541152	-179.28056398	597.74419036	70.73903630
ZSB21	205.06455961	-8.04653372	126.78861563	90.56135316	144.89238753	-74.28640074	63.05752875
ZSB22	-8.04653372	214.49463232	8.36176242	46.81592355	-9.02401477	213.17365065	76.58585028
ZSB23	126.78861563	8.36176242	191.49001290	99.05909747	140.30784318	-51.96940844	73.71559611
ZSB24	90.56135316	46.81592355	99.05909747	178.49480444	87.38035070	5.76895115	80.94502610
ZSB25	144.89238753	-9.02401477	140.30784318	87.30035070	266.04476515	-64.03471256	74.20402362
ZSB26	-74.28640074	213.17365065	-51.96940844	5.76895115	-64.03471256	429.25403220	73.05161291
ZSB27	63.05752875	76.58585028	73.71559611	80.94502610	74.20402362	73.05161291	146.99873130
ZSB28	478.01846243	-345.00657815	417.62246365	275.21146452	561.59887765	-743.06106824	92.03805661
ZSB29	82.07656874	53.75437886	89.22174387	98.22518077	83.01332246	31.10901780	77.39586790
ZSB30	104.36510509	-56.34514400	170.15683148	135.39349479	185.20798579	-176.30735092	66.06663349
ZSB31	183.03038596	-46.27188997	181.20549278	144.66734075	220.97994213	-164.04947369	83.40062255
ZSB32	181.99983135	-50.74860986	167.43480533	111.84460071	191.97004078	-164.61827063	66.24588400
ZSB33	-31.55210037	167.58043876	-15.88761184	40.22838201	-45.05543794	257.76362594	70.83343205
ZSB34	187.88958803	-63.42419233	168.38870065	134.65578734	167.34677384	-191.69437684	50.98658797

Table C-4. Continued

	ZSB28	ZSB29	ZSB30	ZSB31	ZSB32	ZSB33	ZSB34
Intercept	1807.65974278	270.75446772	477.23390103	496.83253062	340.96570393	-308.35914528	502.50258015
PB (Simul.)	-2357.08337788	-130.67150423	-704.00126503	-676.68471197	-651.09629340	530.40685985	-741.73287269
PDF	37.18214307	1.07258946	10.24448194	9.96505225	11.27456110	-9.54616690	11.00876613
FW	917.48645683	72.62628202	370.55224470	280.75768506	262.99062841	-190.72912649	429.19241180
PC	90.29070078	2.37326001	26.31271262	26.03031088	26.38393290	-22.18038859	27.70586504
PAt-1	367.29306354	4.75575941	106.35350622	86.24215570	111.27927425	-99.24432277	117.62320794
PAt-2	-326.96316640	-32.86396599	-91.77062081	-95.55371208	-86.00425425	63.10081104	-96.47325458
S1	-847.68861286	-39.14890735	-251.16131364	-238.62162732	-237.64359003	197.41155724	-265.08763826
S2	-813.49784689	-33.61723277	-240.49766249	-230.39927708	-228.24229356	191.52780562	-252.20649079
S3	-532.32507803	-26.46134981	-154.63304319	-154.48552071	-145.73519880	120.75768631	-159.34424179
E	2045.64169735	114.40476465	578.04095516	639.04185456	530.56670947	-436.41485757	562.07638678
ZSB11	-1084.35714198	26.21640819	-270.15242106	-250.29344808	-262.46953769	346.60633452	-289.11653217
ZSB12	-286.41871841	58.79146382	-38.75240722	-31.95029705	-33.00587517	154.09411806	-42.64406842
ZSB13	-372.56309462	24.81512294	-107.77235461	-78.95578422	-48.15395124	147.02591243	-126.92230606
ZSB14	1592.88770826	147.74983095	490.25414584	538.87488275	461.26616241	-262.08012243	473.82524900
ZSB15	-422.52289900	44.91843290	-78.00517762	-83.20317034	-69.71390105	178.73292134	-81.06922566
ZSB16	-971.14407852	23.65489562	-248.26127230	-215.30235304	-237.75392749	318.94571700	-277.73375076
ZSB17	-62.10197094	60.68714651	29.22639148	24.39039684	30.37078634	95.60193128	29.15940538
ZSB18	-404.19348345	43.42664901	-85.80179533	-73.51517383	-65.36324415	173.58177085	-96.42386210
ZSB19	-23.09111352	69.49347643	40.59590681	61.84752580	27.93434701	101.41548514	26.91882534
ZSB20	-1428.25636832	-6.65052897	-378.88559550	-360.02902311	-351.91594876	409.89492282	-400.88050846
ZSB21	478.01046243	82.07656874	184.36510509	183.03038596	181.99983135	-31.55210037	187.88958803
ZSB22	-345.00057815	53.75437886	-56.34514400	-46.27188997	-50.74860986	167.58043876	-63.42419233
ZSB23	447.62246365	89.22174387	170.15683148	181.20549278	167.43480533	-15.88761184	168.38870065
ZSB24	275.21146452	98.22518077	135.39349479	144.66734075	111.84460071	40.22838201	134.65578734
ZSB25	561.59887765	83.01332246	185.20798579	220.97994213	191.97004078	-45.05543794	167.34677384
ZSB26	-743.06106824	31.10901780	-176.30735092	-164.04947269	-164.61827063	257.76362594	-191.69437684
ZSB27	92.03085661	77.39586790	66.06663349	83.40062255	66.24588400	70.83343205	58.98658797
ZSB28	2701.92401872	210.42346609	791.22564672	848.63975774	742.81883183	-489.45746319	782.11037506
ZSB29	210.42346609	150.15936037	113.18653099	119.50047647	95.00555545	50.99443902	111.80677854
ZSB30	791.22564672	113.18653099	360.29276524	291.33328021	256.52128576	-84.83334042	299.55207436
ZSB31	848.63975774	119.50047647	291.33328021	394.67021756	259.21534820	-86.92635174	277.79085618
ZSB32	742.81883183	95.00555545	256.52128576	259.21534820	323.09362225	-92.73816618	262.02355077
ZSB33	-489.45746319	50.99443902	-84.83334042	-86.92635174	-92.73816618	271.49264725	-88.41996501
ZSB34	782.11037506	111.80677854	299.55207436	277.79085618	262.02355077	-88.41996501	383.40634099

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